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ARTICLES

DDT-RESISTANCE HAZARD IN NORTH AMERICAN POPULATIONS OF *AEDES AEGYPTI*

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Larvae of *Aedes aegypti* (L.) have developed resistance to the DDT used in treatment of breeding foci in certain localities in Trinidad, Haiti, Dominican Republic, Guadeloupe, Puerto Rico, Jamaica, Colombia, Venezuela, French Guiana and Surinam (Blazquez, 1957; Fay, 1959; Fontan and Fauran, 1959; Fox, 1960; Fox *et al.*, 1960; Gilkes *et al.*, 1956; Kerr, 1960; Pan American Sanitary Bureau, 1956, 1957; Sautet and Vuillet, 1956). Many of the Caribbean strains became so DDT-resistant that the LC_{50} approximated 5 p.p.m. DDT (Fay, 1956). Increased DDT-tolerance has also been observed in the field in South Viet Nam (Sautet *et al.*, 1959) and has been developed by laboratory selection in strains from Nigeria (Surtees, 1958) and Malaya (Shidrawi, 1957; Abedi and Brown, 1960). The genetic origin of DDT-resistance in Malayan population (Coker, 1958) has been considered to differ from that in larvae from Haiti or Trinidad (Qutubuddin, 1958).

In view of the interest in eliminating *Aedes aegypti* in parts of the continental United States, studies of DDT-susceptibility levels were made by Evans *et al.* (1960) on larvae collected at New Orleans, La. and Miami, Fla. and tested either immediately or after a generation of laboratory culture. The New Orleans sample showed no resistance, the LC_{50} being 0.013 p.p.m. DDT. On the other hand, the Miami sample was significantly DDT-tolerant, the LC_{50} being 0.07 p.p.m. and 7 percent of the larvae surviving 0.5 p.p.m. DDT.

In order to ascertain whether North American populations of *A. aegypti* were capable of developing the decisive DDT-resistance characteristic of certain Caribbean localities, the New Orleans strain was submitted to five generations of DDT selection pressure in our laboratory. A strain was also obtained from Key West, Fla. and submitted to similar laboratory pressure with DDT. The selection was made on larvae in the 3rd and early 4th stadia, lots of 25 being exposed in 250-ml. glass jars so that the percent mortality could be observed. The selecting levels of DDT were adjusted in each generation so that more than 95 percent mortality was obtained in the first selections and over 90 percent mortality in the later generations. The resulting resistance levels obtained in each succeeding generation were tested by the standard method for mosquito larvae (World Health Organization, 1960).

NEW ORLEANS STRAIN. Eggs of the 10th generation of the laboratory colony maintained at the U. S. Quarantine Station, New Orleans, were supplied by Mr. B. R. Evans in April, 1960; when tested in June they showed an LC_{50} of 0.017 p.p.m. DDT. Selection pressure was then applied for five generations (Table 1), and it was found that the LC_{50} increased to 4.5 p.p.m., the rise being particularly marked between the F_3 and F_4 generations. This decisive increase in resistance was accompanied by a considerable decrease in slope of the dosage-mortality regression line (Fig. 1), indicating that susceptible phenotypes still persisted. Such a situation would allow reversion to occur on relaxation of selection pressure, as was

TABLE 1.—Increase in larval LC_{50} levels (in p.p.m. DDT) of the New Orleans and Key West strains exposed in every generation to selecting doses causing more than 90 percent mortality

	New Orleans		Key West	
Generation	Selecting dose	LC_{50}	Selecting dose	LC_{50}
P		0.017		0.30
	0.04		0.5	
F_1		Not Det.		0.61
	0.04		1.0	
F_2		0.06		0.80
	0.32		2.5	
F_3		0.16		1.3
	1.0		5.0	
F_4		1.4		2.1
	1.0			
F_5		4.6		

found with the Malayan strain by Abedi and Brown (1960); but these authors found that even in such a case resistance would eventually stabilize on resumption of selection.

KEY WEST STRAIN. Eggs were supplied in April 1960 by Dr. G. B. Craig, University of Notre Dame, from a culture originally established by A. O. Lea at the Florida Entomological Research Center, Vero Beach, from adults collected at Key West in November, 1959. When tested in June this strain proved to be already somewhat DDT-tolerant, showing an LC_{50} of 0.30 p.p.m.; it was also tolerant to dieldrin (LC_{50} 0.073 p.p.m.) and to gamma-BHC (LC_{50} 0.60 p.p.m.). Selection pressure was then applied with DDT for four generations (Table 1), and it was found that the LC_{50} steadily increased to 2.1 p.p.m. DDT. The development of this decisive DDT-resistance was accompanied by a gradual flattening of the dosage-mortality regression line (Fig. 1).

CUCUTA STRAIN. Parallel studies were made with a strain from Cucuta, northeastern Colombia, where DDT-resistance had been reported in 1957. The strain under study originated from a larval collection made in November 1959 and was colonized in the Instituto Carlos Finlay, Bogota, by Mr. A. Morales, who found it to be DDT-susceptible (LC_{50} approximately 0.05 p.p.m.). Eggs of this strain were provided by Dr. J. Austin Kerr in May 1960; when reared in our laboratory, it showed a very low oviposition rate. Susceptibility tests performed in August and September showed the strain to be (a) variable, with LC_{50} levels ranging from 0.19 to 0.84 p.p.m., and (b) extremely heterogeneous, the dosage-mortality regression lines having a very low slope and two inflections. It was also somewhat tolerant of dieldrin (LC_{50} 0.09 p.p.m.) and of gamma-BHC (LC_{50} 0.12 p.p.m.). When sufficient parental stock had been obtained in two generations of laboratory culture, selection pressure was applied with 1 p.p.m. DDT. The LC_{50} of the F_1 from selected parents was found to have increased to 4.5 p.p.m. DDT, with a slight further decrease in slope of the d-m line. Similar pressure raised the LC_{50} of the F_2 to 5.1 p.p.m.; subsequent relaxation of pressure left the LC_{50} of the F_3 at 2.2 p.p.m. DDT, the slopes of the d-m lines remaining very low.

SUMMARY. By means of selection pressure in the laboratory, it has been shown that strains of *Aedes aegypti* from New Orleans, La. and Key West, Fla. are capable of developing high DDT-resistance in the larvae, the results paralleling those obtained from a strain from Cucuta, Colombia. It is therefore concluded that the DDT-resistance hazard in populations in the southern U.S.A. is just as high as in Central American regions.

(This work was performed on a grant-in-aid from the National Institutes of Health.)

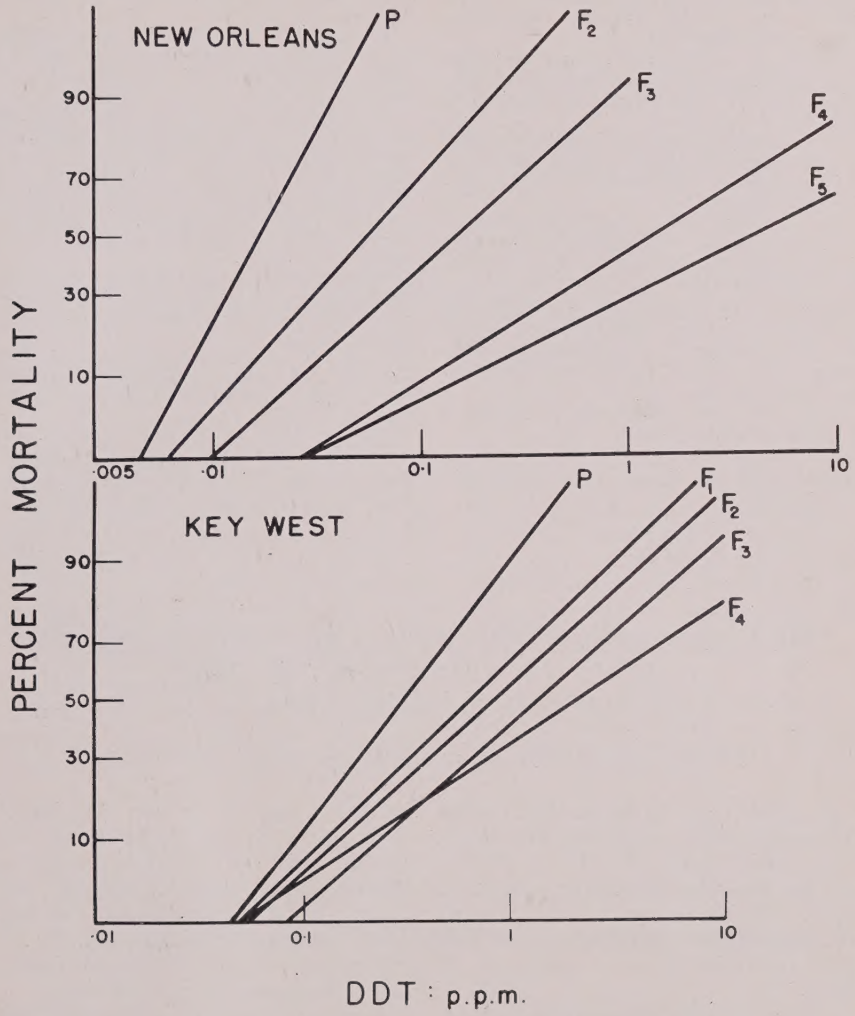

Fig. 1.—Dosage-mortality regression lines for the increasing DDT-resistance of strains of *A. aegypti* from the southern U. S. A. submitted to 4–5 generations of selection pressure.

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FURTHER COMMENTS ON THE SUSCEPTIBILITY OF *AEDES AEGYPTI* TO DDT IN THE MIAMI, FLORIDA, AREA

JOHN E. PORTER,[1] BURTON R. EVANS,[2] AND GEORGE KOZUCHI[1]

An earlier paper by Evans *et al.* (1960) presented evidence suggesting that *Aedes aegypti* (Linn.) from the Miami, Florida, area are somewhat tolerant or resistant to DDT. The tests reported therein showed that 7.0 percent of the *aegypti* larval mosquito population survived 0.5 p.p.m. of DDT.

More recent tests, performed in the same manner, using the WHO test kit and method of testing, show a broad range of reaction to DDT as is indicated in Table 1. The larvae tested are the F_1 generation of field-collected larvae and adults from four different areas of Miami. These are designated as area "A" for the Miami River front; area "B" for larvae found in a coconut stump in a residential section of the city nearly two and one half miles from the river; area "C" for specimens from the Miami International Airport; and area "D" for specimens recovered from tree-holes in the southeastern section of the city.

Larvae of *aegypti* from these four areas show a significant degree of natural variation in their reaction when exposed to DDT. They range from areas "A" and "D" which are relatively susceptible to DDT with an LD-50 of .029 and .028, respectively, to larvae from area "B" which show indications of resistance to DDT with an LD-50 of .22. Populations showing intermediate degrees of susceptibility were those from area "C" having an LD-50 of .138.

1, 2 Public Health Service, Department of Health, Education and Welfare, Quarantine Station, Miami Beach, Florida and New Orleans, Louisiana, respectively.

TABLE 1.—Susceptibility levels of *Aedes aegypti* larvae from Miami, Florida, to DDT after 24 hours

Concentration of insecticide in test suspensions	Total no. of larvae used				Percent mortality			
	A	B	C	D	A	B	C	D
.004 p.p.m.	...	158	..	50	....	0	....	0
.02 p.p.m.	154	158	29	49	0	.63	10.3	0
.1 p.p.m.	153	158	30	50	55.6	13.3	30.0	56.0
.5 p.p.m.	141	158	30	50	99.3	89.2	90.0	98.0
Control	153	158	28	50	0	0	0	0

TABLE 2.—Comparison of past and present LD-50 levels for *Aedes aegypti* larvae from Miami, Florida, to DDT after 24 hours

1959 LD-50 (Evans *et al.* 1960)	1960 LD-50			
	A	B	C	D
.07	.029	.22	.138	.028

Examination of Table 2 shows that it may now take 3 times the amount of insecticide to get an LD-50 as it did in the tests reported upon by Evans *et al.* (1960).

The spotty, but evident development of populations of *Aedes aegypti* in Miami, Florida, which are resistant to DDT made it advisable to change our method of treating breeding receptacles. Since July 1960 it has been observed in the field operations for *Aedes aegypti* control that paris green remains effective for several months as a larvicide where, previously, DDT was unable to prevent the re-establishment of *aegypti*. Although the use of paris green was not of a controlled nature, it tends to support the new data regarding the resistance or tolerance of *Aedes aegypti* larvae in the Miami, Florida, area to DDT.

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DESPLAINES VALLEY MOSQUITO ABATEMENT DISTRICT

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CENTRAL UTAH COUNTY, UTAH, MOSQUITO SURVEY STUDIES

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INTRODUCTION

Under the sponsorship of the City-County Health departments of Utah County, and at their request the Zoology and Entomology Department at Brigham Young University conducted a mosquito survey of Central Utah Valley in Utah County from July 1, 1958 through August 31, 1959.

Principal objectives were the determination of species present, and their geographic distribution; the seasonal population and the general biology of each species; the determination of vector potential for transmissible diseases especially encephalitis, and the formulation of recommendations for control.

Roy J. Myklebust, sanitarian and entomologist (at present with the Washington State Department of Health), was employed as director of the survey from July 1958 until April 1959, with D. Elden Beck of the Brigham Young University Zoology Department as project supervisor. Several graduate students from the Brigham Young University and members of the City-County Health departments served as field and laboratory technicians under the direction of Stanley K. Taylor, graduate student. Dr. Lewis Neilsen, entomologist at the University of Utah, assisted with certain technical aspects of the project, as did also Glen C. Collett of the Salt Lake City Mosquito Abatement District, and Jay Graham of Salt Lake County Abatement District. The Rocky Mountain Laboratory, U.S.P.H.S., at Hamilton, Montana, supplied biological materials and cooperated in giving inservice training to some of the personnel employed on the survey. Dr. James M. Brennan of the Rocky Mountain Laboratory was especially helpful in counsel, regarding research on *Culex tarsalis*. Mr. Stanley K. Taylor made a special study of *Culex tarsalis* during the period of this survey. His project was in part supported by research funds from the Provo City, Utah, Rotary Club. Much of the information in this report on *Culex tarsalis* is taken from Taylor's data. The Utah State Department of Health, the U.S.D.A., Animal Disease Eradication Division, and the U. S. Soil Conservation Service also contributed valuable data and other services to the survey. The people of Central Utah Valley cooperated wholeheartedly in every instance, which made the work pleasant and contributed much to its success.

METHOD OF STUDY AND GENERAL OBSERVATIONS. After preliminary surveys, 125 collection stations were established. The stations were selected to facilitate studies of all possible aspects of mosquito biology. They were visited weekly throughout the breeding season. Periodic and systematic collections were made so that population data could be analyzed on a statistical basis. Most of the larval collections were returned alive to the laboratory and reared to adults. Adults were collected by aspiration, sweep netting and by light traps. The laboratory procedures involved rearing immature forms to adulthood, mounting the specimens for identification and organizing data to be used for future analyses.

Utah County as a whole has a total area of 2,143 square miles. Most of the land is unirrigated, range and forest land, constituting approximately 1,709 square miles. Utah Lake covers about 145 square miles, varying in size with seasonal change in water supply and drainage. Provo River is the main stream emptying into Utah Lake. Crop and pasture land constitutes about 235 square miles. Municipalities, airports, industrial plants, roads etc. constitute about 58 square miles. Central

Utah Valley, which contains Utah Lake covers approximately 438 square miles.

A survey of the natural and man-made mosquito situations revealed the following 5 genera and 20 species to be present. The figures in parentheses following some of the names indicate the relative density of the ten most common species, (1) being the most abundant, (2) next, etc.: *Anopheles freeborni* (9); *Culiseta incidens, C. inornata* (2); *C. impatiens; Mansonia perturbans; Aedes campestris* (10); *Ae. dorsalis* (3); *Ae. excrucians; Ae. fitchii; Ae. flavescens; Ae. increpitus, Ae. melanimon; Ae. nigromaculis* (5); *Ae. niphadopsis* (6); *Ae. vexans* (7); *Ae. cinereus; Culex erythrothorax* (4); *C. pipiens* (8); *C. salinarius,* and *C. tarsalis* (1).

Larval habitats in the valley were separated into nine general categories, as shown below. Unusual species (rare), or those representing an isolated single brood appearance are not listed.

1. Permanent roadside pools more or less due to subsurface flow: Here were found *Anopheles freeborni, Culiseta inornata; Aedes campestris; Ae. dorsalis; Ae. increpitus; Ae. nigromaculis; Ae. vexans; Culex pipiens; C. tarsalis,* with *C. erythrothorax* being found occasionally and the others in varying populations.

2. Intermittent roadside pools due to spring snow melt, rainfall run-off from torrential rains, and drainage resulting from excess irrigation in nearby fields: Present were *A. freeborni; Culiseta inornata; Ae. campestris; Ae. dorsalis; Ae. nigromaculis; Ae. niphadopsis; Ae. vexans; Culex erythrothorax; C. pipiens; C. tarsalis,* with *Aedes dorsalis, Ae. nigromaculis, Ae. niphadopsis, Ae. vexans, Culex pipiens;* and *C. tarsalis* predominating.

3. Marshland pools associated with the rise and fall of lake level, flooding due to snow melt and spring run-off, torrential rains plus change in ground water level and natural springs: Present were *Culiseta incidens; C. inornata; Aedes campestris; Ae. dorsalis; Ae. nigromaculis; Ae. vexans; Culex erythrothorax; C. pipiens; C. tarsalis,* with *Ae. vexans* and *Culex tarsalis* predominating.

4. Slowly moving streams with abundant plant growth at stream banks or as emergent vegetation in the streams themselves: Present were *Anopheles freeborni; Culiseta inornata; Aedes vexans; Culex erythrothorax; C. pipiens; C. tarsalis* with *Anopheles freeborni, Aedes vexans, Culex erythrothorax* and *C. tarsalis* predominating.

5. Artesian wells: Present were *Anopheles freeborni; Aedes dorsalis; Ae. vexans; Culex tarsalis,* with *Anopheles freeborni* and *Culex tarsalis* predominating.

6. Irrigation ditches on farm and pasture lands: Present were *Culiseta inornata; Aedes campestris; Ae. dorsalis; Ae. vexans; Culex erythrothorax; C. pipiens; C. tarsalis* with *Aedes campestris, Ae. dorsalis, Ae. vexans* and *Culex tarsalis* predominating.

7. Abandoned excavations as gravel pits, excavation for levee construction, cellars etc.: Present were *Anopheles freeborni; Culiseta inornata; Aedes dorsalis; Ae. nigromaculis; Ae. vexans; Culex erythrothorax; C. tarsalis* with *Aedes dorsalis, Ae. vexans, Culex erythrothorax* and *C. tarsalis* predominating.

8. Street gutters, gutter underpasses at street intersections in cities and towns: Present were *Aedes dorsalis; Ae. vexans; Culex erythrothorax; Culex pipiens; C. tarsalis,* with *Ae. dorsalis, Culex erythrothorax* and *C. tarsalis* predominating.

9. City park ponds and ornamental residential pools: Present were *Culiseta inornata; Aedes dorsalis; Ae. nigromaculis; Ae. vexans; Culex erythrothorax; C. pipiens; C. tarsalis,* with *Aedes dorsalis, Culex pipiens* and *C. tarsalis* predominating.

Several species were collected in the larval stage during the winter. Most of these were found in marshland situations in pools of water covered by ice. The following were collected in such places: *Culiseta incidens; C. inornata; Aedes campestris; Culex erythrothorax* and *C. pipiens.*

Overwintering adult mosquitoes collected during this survey were *Anopheles freeborni,* found in abandoned buildings, barns and airplane hangers; *Culex erythrothorax,* for the most part in potato and fruit cellars, and also in abandoned build-

ings, associated with *Anopheles freeborni;* and *Culex tarsalis,* found under rocks in stream beds at the mouths of American Fork, Provo and Rock Canyon, beneath stones in talus slopes at the north end of the valley near Saratoga and at the south end of the county near Goshen.

Anopheles freeborni and *Aedes niphadopsis* were rarely caught in the light trap. *Aedes campestris* and *Aedes nigromaculis* were taken as occasional visitors. The species which were abundant in light traps were *Aedes dorsalis; Ae. vexans, Culex erythrothorax; C. pipiens;* and *C. tarsalis.* It might be suspected that *Aedes increpitus, Ae. cinereus, Ae. excrucians, Ae. fitchii* and *Ae. flavescens* would have come to light traps had the traps been placed in the areas of breeding, namely, at higher elevations and in mouths of nearby canyons.

Species of mosquitos collected by net sweeping and by baiting (human and domestic stock) were: *Anopheles freeborni,* which fed most actively after dusk and at dawn; *Culiseta inornata,* which actively fed on cattle and horses during day and night; *Mansonia perturbans,* which was observed to bite man in early evening; *Aedes campestris,* which fed on man both day and night but more so in late afternoon and evening; *Aedes dorsalis,* which fed on man both day and night but was most active at dusk and dawn. *Aedes increpitus* fed on man in late afternoon and evening; *Aedes nigromaculis* fed on both man and domestic stock during day and night, but was most active during evenings; *Aedes niphadopsis* fed on man and cattle during the day and evenings but was most active during late afternoon and evening; *Aedes vexans* actively fed on man during the day when the sky was overcast, and in shaded situations, but was most active at dusk and after dark; *Culex erythrothorax* was observed to bite both day and night but was most active in the evening; *Culex tarsalis* feeding on man, started to bite at dusk, but was most active about one hour after dark. It is interesting to note that *Aedes dorsalis, Ae. niphadopsis, Culex erythrothorax,* and *C. tarsalis* were found distributed more than six miles from a known point of larval origin. Other species seemed to be relatively close to their larval habitats.

DISCUSSION. Central Utah Valley is a catchment basin for waters from the high Wasatch Mountain Range and from those mountain ranges still further to the east. Some of the drainage courses are permanent, as rivers and smaller streams, while in others the flow is periodic, resulting from spring snow melt or seasonal torrential rains. There are also many springs which issue at the foothills, benchlands, and marshlands bordering the eastern side of the valley, all of these waters reaching the basin to form Utah Lake.

Since the date of the first pioneer settlement in the valley, irrigation has been practiced in crop production. Diversion of waters from their natural courses has made marked changes in mosquito ecology. It was concluded from this survey that the primary source for mosquito production affecting the welfare of man in Central Utah Valley was either directly or indirectly related to the diversion of these waters for purpose of irrigation.

The principal mosquito-breeding situations in cities and towns of Central Utah Valley were due to improper curb and gutter construction, especially at street intersections. Water continually running in the gutter channels prevented mosquito breeding at the intersections or elsewhere. However when the flow was discontinuous, the water ponded in the culverts beneath the street intersections and allowed for a most favorable source of mosquito breeding. Discontinuous flow came about from periodic watering turns in urban garden irrigation. Parking sprinklers also contributed to ponding in gutters attended by trash accumulation.

Another factor which contributed to county-wide mosquito production was a combination of poor irrigation in farm management, associated with improper highway construction. When fields were flooded, excess water drained to highway borrow pits, which were so constructed

that the water did not drain away. Also in farm management, apart from drainage to highway borrow pits was the accumulation of water on farmlands themselves which contributed to mosquito breeding.

It is interesting to note there is no published record of a disease organism found in the body of a mosquito species occurring in Utah Valley. Nevertheless, Western equine encephalitis, a mosquito borne disease has been identified in both man and domestic stock in Utah Valley with fatal consequences to both. Following is a list of species of mosquitoes which were found to occur in Central Utah Valley, which have been convicted as vectors of disease organisms in other parts of the country.

Species of Mosquito	Disease
Anopheles freeborni	Western equine encephalitis, malaria
Culiseta inornata	Western equine encephalitis
Mansonia perturbans	Western equine encephalitis
Aedes dorsalis	St. Louis encephalitis, Western equine encephalitis
Aedes vexans	Western equine encephalitis
Culex pipiens	St. Louis encephalitis, Western equine encephalitis, virus of fowl pox, heart worm of dogs
Culex tarsalis	Western equine encephalitis

Those species of pest importance to man include *Aedes dorsalis, Ae. campestris, Ae. nigromaculis, Ae. niphadopsis, Ae. vexans, Culex erythrothorax, C. tarsalis, Mansonia perturbans,* and *Anopheles freeborni.*

Culiseta inornata, Ae. dorsalis, Ae. campestris, Ae. nigromaculis, Ae. niphadopsis, Ae. vexans, Culex pipiens, C. tarsalis and *Anopheles freeborni* were found to attack domestic stock as well as man. *Culex tarsalis* and *Culex pipiens* were especially bothersome to poultry.

From a seasonal point of view, those species which were active in early spring as biters were *Anopheles freeborni, Ae. campestris, Ae. fitchii, Ae. increpitus, A. niphadopsis, Culex erythrothorax,* and *C. tarsalis. Aedes campestris* and *Ae. niphadopsis* appeared early in the spring and had peak population in early summer. All other pest species made their appearance in early spring and had population peaks in mid and late summer. This was especially true of *Ae. dorsalis, Ae. vexans, Culex erythrothorax, C. pipiens,* and *C. tarsalis.*

Space does not allow inclusion of the seasonal population analyses which were obtained for each of the twenty species examined in this study. Ten species were significant in the larval collections. Listed in descending order of population density were *Aedes dorsalis, Culex tarsalis, Culiseta inornata, Aedes nigromaculis, Culex erythrothorax, Ae. vexans, Culex pipiens, Ae. campestris, Ae. niphadopsis, Anopheles freeborni.* These data on population were obtained from larval counts made from collections taken at selected field stations. In light trap collections, the predominant species in descending order of abundance were, *Culex erythrothorax, C. tarsalis, Ae. dorsalis, Ae. nigromaculis,* and *Ae. campestris.* Figures 1, 2, 3, and 4 present a graphic analysis of four of the most numerous species.

Information on hibernation was mentioned previously for those species of larvae which were found overwintering under ice. Most attention in the hibernation studies was directed to *Culex tarsalis,* due to its being suspect in western equine encephalitis transmission. It was found to hibernate under rocks in talus slopes at various places around the valley and beneath stones in creek beds at the mouths of canyons along the Wasatch Range.

Searching for adult *Culex tarsalis* in cellars, barns, abandoned buildings in and around residential areas, farmstead hay stacks, and along overhanging stream banks revealed instead the presence of other species of gravid female mosquitoes. The most common species in these places was *Culex erythrothorax,* which was found in populations of from one to fifty or more specimens. The next most common was *Anopheles freeborni.* The latter species, when returned to the laboratory immediately became active, fed readily on humans, and later laid eggs. For some unknown reason, the larvae from these eggs did not develop further than the third instar.

Recommendations for Control. It was proposed that first priority be given to

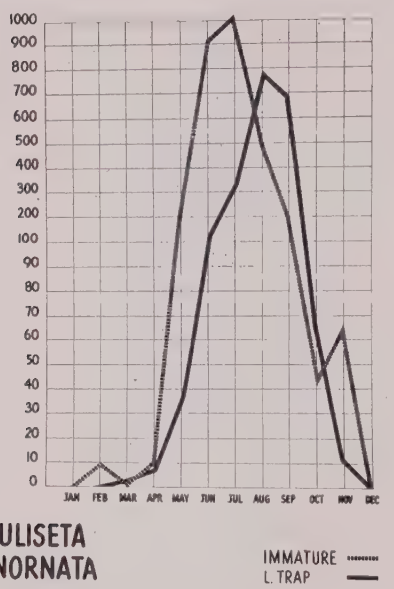

FIG. 1.—Seasonal variation in collections of larvae (immature), and adults from light traps in one year.

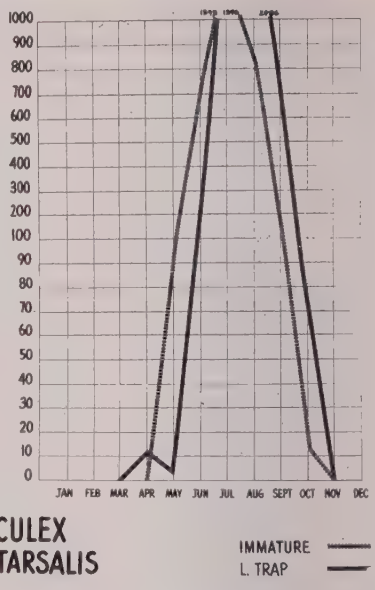

FIG. 3.—Seasonal variation in collections of larvae (immature), and adults from light traps in one year.

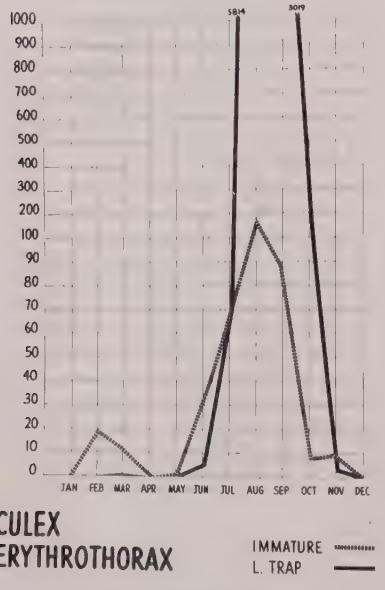

FIG. 2.—Seasonal variation in collections of larvae (immature), and adults from light traps in one year.

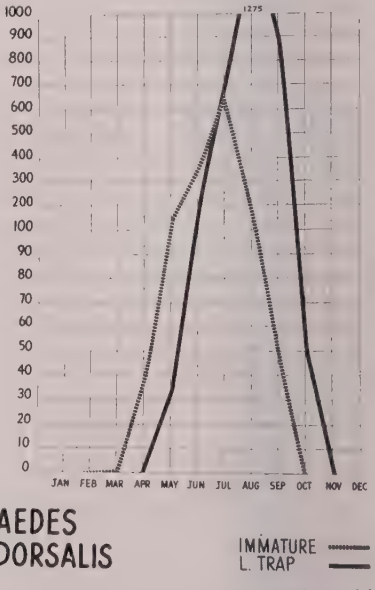

FIG. 4.—Seasonal variation in collections of larvae (immature), and adults from light traps in one year.

measures of permanent control (sanitation), and that temporary control by insecticides be secondary. It was recommended that long range, county-wide, overall planning be immediately considered to establish the control measures. The various agencies which would be involved were:

1. Departments concerned with the supervision and construction of streets, curbs, gutters, and sewers in towns and cities.
2. Departments concerned with county, state, and federal highway construction.
3. Departments involved with private or public agencies which impound or distribute water for recreational, agricultural or other purposes such as boat harbors, land reclamation and airport construction.
4. Agricultural and industrial organizations, individuals or institutions.
5. Public and private agencies concerned with sewage and garbage disposal.

As an overall policy, it was recommended that sound engineering planning and construction of public and private game preserves, boat harbors, airports, and parks to be used for commercial or recreational purposes should include measures for control of mosquito breeding situations.

In accordance with accepted policy of good mosquito control anywhere, it was recommended that a full-time supervisor or manager be employed to head the direct organization of control.

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JUST PUBLISHED!
AMCA BULLETIN NO. 4
ORGANIZATION FOR MOSQUITO CONTROL

THE BIOLOGY AND DISTRIBUTION OF THE ROCKPOOL MOSQUITO, *AEDES ATROPALPUS* (COQ.)[1]

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INTRODUCTION. The rockpool mosquito is of interest and importance for several reasons. In the laboratory it is a known vector of organisms pathogenic to man. In the vicinity of its breeding habitat it is a persistent and annoying species, biting freely during the day. The distribution and biology of the species have not been well studied. The systematic relationships of the species are not clear; in fact, it is possible that this insect may prove to be a species complex. No detailed study of the habitat, i.e., rockpools, had been made. It has been difficult, if not impossible, to separate the instars of field-collected larvae.

For all of these reasons, it was concluded that an investigation of the biology and distribution of *Aedes atropalpus* would be fruitful. The studies were begun in 1956 and concluded in 1960. From July 1, 1956 to June 30, 1957 funds from U. S. Public Health Small Grant E1351 supported the work of the project.

During the course of the investigations, thousands of specimens were collected and several hundred were reared. Some 650 specimens were prepared as permanent mounts.

GEOGRAPHICAL DISTRIBUTION. Carpenter and Lacasse (1955) recorded *Aedes atropalpus* from Labrador to El Salvador. It extends from the eastern seacoast to Minnesota, Kansas, Missouri, Oklahoma, Texas and Arizona. In addition, Dyar, 1928, had reported this insect from Costa Rica and Nicaragua. Rees and Nielsen, 1955, recorded *Aedes atropalpus* from Utah. Pratt (1957) collected what he considered to be *Aedes atropalpus epactius* from Guatemala City, Guatemala. There are no published records of the presence of this mosquito along the Pacific coastal area of the United States, and correspondence with specialists indicated no knowledge of its occurrence on the West Coast.

The available records in many instances are far from specific. It was considered that detailed records indicating spatial and seasonal distribution would be valuable. The following represent new records obtained or first reported during these investigations.

Canada:—Cooper, Ontario, August 1955; Vockeroth, Tadoussac, Quebec, August 1939; Smith, Norway Bay, Quebec, August 1938; Shewell, St. Gideon, Quebec, July 1939, Smith.

Guatemala:—Guatemala City, October 1957, Pratt.

United States: Maine—Along shore (Anemone Cave—Otter Cliff), Mt. Desert Island, May–October, Shaw; Bernard, July 1956, Shaw; Popham Beach, 1956, Shaw; Salmon Falls, Saco River, 1939, Hanson; Baxter State Park, July 1948, Smith; Goose Rock, July 1956, Shaw.

New Hampshire: North Munroe, April, August 1956–57, Shaw; Woodsville, April, August 1956–57, Shaw.

Vermont: East Barnett, April–October 1956, Shaw; Passumsic, August 1956, Shaw; Halifax Gorge, Halifax, August 1956, Shaw; Route 103 near Ludlow, August 1956, Shaw and Lavigne.

Massachusetts: Charlemont, September 1934, Mass. Mosquito Survey; Chesterfield Gorge, Chesterfield, May–October 1957, Shaw and Maisey; Cohasset, August 1958, Wells; Florence, May 1957, Shaw and Maisey; Green River, Colrain, 1956, Shaw; Hull, 1955, Wells; Huntington, August 1957, Maisey; Loudville, April–November, 1956–58, Shaw and Maisey; Rockport, Au-

[1] Contribution No. 1337 of the Department of Entomology and Plant Pathology, and Misc. Contribution No. 1016 of the Massachusetts Agricultural Experiment Station, University of Massachusetts.

gust 1957, Smith; Scituate, 1955, Wells; Turner's Falls, August 1957, Maisey; Waconah Falls, Dalton, September 1956, Shaw; Windsor Jams, Windsor, September 1956, Shaw.

New York: South Inlet, Webb, May 1951, Jamnback.

Maryland: Gunpowder River, Baltimore Co., May 1956, Craig.

Georgia: Milledgeville, Pratt; Tallulah Gorge, March 1950, Cole and Wall.

Texas: Onion Creek, Travis Co., September 1943, D.E.E.

Since this species frequently occurs in the vicinity of waterfalls and since there are commonly towns or cities near such locations, it is likely that *Aedes atropalpus* causes much more annoyance than is generally believed.

Biological Observations. *Aedes atropalpus* is multiple-brooded. In Loudville, Massachusetts (elevation approximately 400′), larvae have been collected from April 5 to November 13. In Chesterfield, Massachusetts (elevation approximately 700′), larvae were collected from May 9 to October 20. At East Barnett, Vermont, larvae were taken from April 7 to October 12. Larvae have been collected from Mt. Desert, Maine, from May 12 until October 22. It has been noted that the first instar larvae can be found in rock pools about the time when pussy willows and soft maples come into bloom.

Under field conditions in Massachusetts, it was observed that the larvae would develop from egg to the fourth instar in 22 days in late April and early May. During late May and early June, the same development required about 11 days. In July, development from the egg to the pupal stage was completed in 14 days. As cold weather approaches, the length of the developmental period increases, thus only fourth instar larvae and pupae were collected between October 16 and November 8, 1958. It is believed that this species overwinters only in the egg stage in this area.

Newly hatched larvae were segregated and reared at room temperatures during July and August. The length of the developmental period varied from 12–17 days with a mode of 13. The first two instars each required 2 to 3 days with a mode of 2 days, the third instar required 2–3 days with a mode of 3 days, and the fourth instar 4–5 days with a mode of 4. The pupal stage required from 2–3 days with a mode of 2.

The insects were reared from newly hatched larvae to the adult stage at constant temperatures of 60°, 70°, 80°, 90° and 93° F. Attempts to rear larvae at temperatures of 40° and 50° F. were not successful. A summary of the results is given in Table 1.

TABLE 1.—Relationship of temperature to length of development from newly hatched larva to adult stage of *Aedes atropalpus*

Temperature ° F.	Length of development in days
60	31
70	17.2
80	11
90	8.1
93	7.7

It was concluded that the threshold of development was between 40° and 50° F. and that the optimum was in the vicinity of 90°. It will be noted that a shorter developmental period occurred at 93° F. but approximately 20 percent fewer insects emerged than at 90°.

In an attempt to determine the sex ratio and whether or not both sexes emerged at the same time, 25 fourth instar larvae and 25 pupae were segregated. From these, 38 adults emerged, of which 20 were males and 18 were females. The males emerged in greater numbers at first, thus by the second day of the pupal period 12 males but only 5 females had emerged.

In another study, 119 pupae were collected in the field. From these 95 females and 24 males were reared. It is possible that some of the males had already emerged by the time the collection was made.

Attempts to induce oviposition were not very successful. In the few instances where the females oviposited, it was noted that the period from emergence to oviposition

was from 5–7 days. Some eggs were deposited by females in the laboratory, but the bulk of the eggs was collected in the field or obtained from Dr. George Craig.

In nature, the insect overwinters in the egg stage. The factors causing hatching are not known but it is believed that temperature must be related to hatching. When eggs are recovered in the field and brought to the laboratory, they usually hatch within 2–4 days.

EFFECTS OF SOME ECOLOGICAL FACTORS. In order to determine the effects of some of the physical factors in the environment on the immature stages of the rockpool mosquito, certain measurements were made.

The temperatures of the water in the rock pools, of the rock surface adjacent to the pools and of the air were recorded. Larvae were found in water at temperatures as low as 40° F. and as high as 96° F. Temperatures of the rock surfaces near the pools ranged from 60°–116° F.

To determine the influence of salinity, samples of water from the rock pools were taken to the laboratory. Using the Mohr test, the salinity was found to be 0.6–2.5 ppm. Unfortunately, samples of water from rock pools near the ocean were not analyzed. Undoubtedly these would have had a higher salinity.

Samples of water were analyzed for oxygen and carbon dioxide. They were found to average 7.3 and 3 ppm respectively.

During the greater part of the investigations, the acidity or alkalinity of the water was determined using Hydrion pH test papers. By this means, pH was found to vary from 3.5–5.5 with a mean of 4.3. During the latter part of the studies, it was possible to determine the acidity or alkalinity using a Beckman pH meter. By this means the pH was determined to lie between 6.4 and 7.5 with a mean of 7.07.

While making collections of larval *Aedes atropalpus* several other insects were noted. Most of these were species of mosquitoes, but predacious diving beetles and dragonfly naiads were also found. It is believed that both of these latter forms prey on *Aedes atropalpus,* since it has been noted that where these occur the larval populations of the rockpool mosquito were relatively low.

Our observations on the insects associated with larval rockpool mosquitoes are summarized in Table 2.

TABLE 2.—Organisms found living in association with *Aedes atropalpus*

Name of organism	Number of observations
Culex restuans	16
Culex pipiens	7
Culex territans	5
Anopheles punctipennis	7
Aedes canadensis	1
Aedes vexans	1
Chironomidae	3
Dytiscidae	2
Odonata naiiads	2
Cyclops	4

It was observed that *Aedes atropalpus* appeared to thrive in water containing green algae, probably *Spirogyra.* In fact, larvae were observed to feed on this plant.

Most of the rock pools contained residues of decomposing leaves, twigs and other organic matter. These materials, together with the bacteria and protozoa associated with them, are believed to be the major sources of food for this mosquito in nature.

BIOMETRICAL OBSERVATIONS. Shaw made measurements of the various structures of 220 mounted larvae. He found the siphonal index to vary from 1.59–3.33 with a mean of 2.16. The width of the head capsule varied from .825–1.095 mm with a mean of .965 mm. The number of pecten teeth varied from 11–29 with a mean of 21.2. The number of comb scales was found to vary from 14–64 with a mean of 36. Both the upper and lower head hairs were single in all but two instances. In these the left hairs were two-branched. The number of branches of the antennal hair varied from 1–6 with a mode of 3 and a mean of 3.9. The siphonal tuft was found to be within the pecten in all but two instances, the number of teeth beyond the tuft varying from 0–4 with a mean of 2.6 and a mode of 2.0.

Maisey concluded, as a result of the measurement of 249 field-collected, unmounted larvae, that widths of the head capsules of the four instars of *Aedes atropalpus* were as follows (Table 3):

TABLE 3.—Head width of *Aedes atropalpus*, in mm

Instar	Mean	Range
1	.285	.252– .322
2	.442	.389– .489
3	.707	.616– .784
4	.980	.819–1.170

He also determined the width of siphon of 254 field-collected larvae as follows (Table 4):

TABLE 4.—Width of siphon of *Aedes atropalpus* in mm

Instar	Mean	Range
1	.075	.056–.102
2	.127	.111–.153
3	.219	.154–.263
4	.346	.266–.529

He determined the length of siphon of 250 field-collected, unmounted larvae to be as follows (Table 5):

TABLE 5.—Length of siphon of *Aedes atropalpus* in mm

Instar	Mean	Range
1	.085	.046–.112
2	.239	.168–.311
3	.412	.378–.448
4	.666	.462–.868

The siphonal index (length of siphon to its width) has been determined from Maisey's data to be as shown in Table 6.

TABLE 6.—Siphonal index of larvae of *Aedes atropalpus**

Instar	Mean index
1	1.13
2	1.88
3	1.88
4	1.92

* Based on mean widths and lengths of the siphon.

Carpenter and LaCasse indicate that the siphonal index varies from 1.6–2.0. Shaw found it to vary from 1.46–3.33 with a mean of 2.14, on the basis of measurements of larvae mounted on slides. Maisey's determinations based on the measurement of unmounted larvae indicate a mean of 1.13 for first instar and 1.92 for fourth instar larvae. It appears that measurements based on specimens mounted on slides are much more variable.

Observations on the Ventral Brush. In 1902, Dyar claimed that the fourth instar could be distinguished from the third and second by the ventral brush being confined to the barred area. The problem of the more proximal hairs in the ventral brush is a puzzling one, and various workers have not been consistent in their use of this term. Stone, Breland and Bohart, in their definitions of this term, have omitted reference to the proximal hairs of the ventral brush which may or may not have sclerotized bars but are detached from the lateral sclerotizations. Belkin, however, in his definition considers the detached hairs to be outside the barred area and states that they have a very small basal sclerotization which is not extended as a transverse bar. In this investigation, observations disclosed that usually the detached hairs of the third and fourth instar larvae have transverse bars. In addition, in most second instar larvae the hairs of the ventral brush have transverse bars but lack lateral sclerotizations.

Table 7 shows the results of observations made on the barred area of second, third and fourth instar larvae.

These results prove that the confinement of the ventral brush to the barred area cannot be used as a reliable criterion to distinguish 4th instar larvae from those of the 2nd and 3rd instars. Hence Dyar's supposition is repudiated.

It had been hoped that during this study some conclusions could be drawn concerning the validity of the two races *Aedes atropalpus atropalpus* and *Aedes atropalpus epactius* as recognized by Dyar in 1928. However, only a limited number (10) of specimens of the western race (*A. atropal-*

TABLE 7.—Distribution of Ventral Brush on the Barred Area

Larval instar	Reared Larvae Confined	Not confined	No. of specimens observed
2nd	1	24	25
3rd	9	13	22
4th	20	1	21
Larval instar	**Field-Collected Larvae Confined**	**Not confined**	**No. of specimens observed**
2nd	0	35	35
3rd	37	13	50
4th	52	3	55

pus epactius) were available. Through the kindness of Dr. Harry D. Pratt, four specimens of what were considered to be *epactius* from Guatemala were made available.

The width of the head capsules, length and width of the siphon, and the siphonal index of specimens from Texas, Guatemala and the northeastern United States were compared. With the exception that the size of the Texan and Guatemalan specimens was larger and the siphonal index less than in the material from the Northeast, the measurements seem to overlap. Due to the few specimens available of *Aedes atropalpus epactius,* it is unwise to attempt to draw conclusions at this time.

SUMMARY AND CONCLUSIONS

1. *Aedes atropalpus* (Coq.) is multiple-brooded. In Massachusetts, the immature stages have been recovered from early April to mid-November.

2. At room temperatures, the developmental period from newly hatched larvae to adult varied from 12–17 days with a mode of 13.

3. Based on rearing experiments in the laboratory, the threshold of development appears to be between 40°–50° F. and the optimum about 90° F.

4. Temperatures in rock pools during periods when *Aedes atropalpus* was developing ranged from 40° to 96° F. Temperatures of the rock surface near the pools varied from 60°–116° F.

5. The siphonal index based on measurements of mounted specimens ranged from 1.59–3.33 with a mean of 2.16. Similar measurements of unmounted specimens indicate means of 1.13, 1.88, 1.88 and 1.92 respectively for 1st, 2nd, 3rd and 4th instar larvae.

6. Dyar's hypothesis that the 4th instar larvae of *Aedes atropalpus* can be distinguished from earlier instars by the confinement of the ventral brush to the barred area is untenable.

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HIBERNATION OF MOSQUITOES IN KOREA

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Korea is located between 124° 11″ and 131° 52″ East-longitude and between 32° 30″ and 43° 00″ North-latitude. It is in the temperate zone and has four distinct seasons.

The meteorological data for the period of the present study were obtained in Seoul by the Central Meteorological Office, as given in Table 1.

Mosquito-borne diseases, including malaria, filariasis, and Japanese B encephalitis, occur in Korea. *Anopheles sinensis* Wiedemann has been regarded as a malaria vector, and *Culex tritaeniorhynchus* Giles as an encephalitis vector. The vectors, or vector of filariasis are not yet definitely known.

Kobayashi (3) reported that *A. sinensis* passes the winter season in the adult stage.

The present investigations on mosquito hibernation and physiology were carried out systematically in the vicinity of Seoul during the period of November 1959–April 1960. Random survey was also done in Kimhae, near Pusan (southern part of Korea), in December 1959.

The Mosquito Species and Their Hibernating Places. During the survey, 5,262 adult mosquitoes were collected. All were females except six male *Culex* (*Culex*) *pipiens* Linnaeus 1758. *C. pipiens* occupied about 97 percent of the total number caught; the rest were *Anopheles* (*Anopheles*) *sinensis* Wiedemann 1825, *Anopheles* (*Anopheles*) *sineroides* Yamada 1925, and *Culex* (*Culex*) *orientalis* Edwards 1921.

Searches were made in numerous localities for what appeared to be suitable hibernating places (4), such as basements, roofs, barns, air shelters, natural and man-made caves, cement tanks, cisterns, wells, rock cracks, tree holes, underneath bridges, animal stables, culverts, empty jars, piles of straws, etc. The majority of the hibernating mosquitoes were found inside caves and long culverts where temperatures and humidity were higher than outdoors. The results of the survey are given in Table 2.

The last fed *sinensis* was caught on 5 November 1959 and the first fed one on 10 March 1960. The first fed *sineroides* was collected on 24 March. All of these were found in the cow stables.

The Hibernating Condition of Mosquitoes. It was observed that the mosquitoes in hibernating condition were resting on the walls or ceilings in the places where they passed the winter seasons. Those resting inside the caves, where temperatures and humidity were higher than outside, were sometimes very active; occasionally hovering and flying around. The mosquitoes became more active when they were stimulated by breathing and light.

On a very cold day of January, when it was —10° C. outside and 2–3° C. inside the culvert, the mosquitoes in the long culvert were gathered closely along the

TABLE 1.—Meteorological data

		November	December	January	February	March	April
Temperature (C.)	Average	10.6	1.1	—3.3	1.7	6.7	12.4
	Maximum	19.5	14.3	10.8	13.7	18.1	25.3
	Minimum	—5.5	—12.9	—17.6	—8.6	—5.8	—0.9
Relative humidity (%)	Average	69	67	63	64	65	59
Sunshine hours	Total	153.5	135.4	148.7	168.0	181.7	239.8
Precipitation (mm)	Total	27.9	34.1	4.6	4.0	113.6	19.0
Snowfalls (mm)	Total	0	0	0	10.4	0	0

TABLE 2.—Hibernating places of mosquito adult females

Localities	Total No. females caught	*A. sinensis*		*A. sineroides*		*C. pipiens*	*C. orientalis*
		f.	uf.	f.	uf.		
Underneath bridges	49	..	6	..	1	39	3
Culverts	4,380	..	22	..	8	4,338	12
Caves	796	..	..	..	2	789	5
Air shelters	12	..	..	..	..	12	..
Cow stables	19	17	..	2	..	..	..
Total	5,256	17	28	2	11	*5,178	*20

* All unfed.

crack of the wall or the ceiling and were not disturbed even by strong breathing and light.

It was also noticed that many dead mosquitoes were still attached to the wet walls of caves.

Hackett (1) and Swellengrebel and de Buck (9) have stated that some mosquito adults in hibernating condition show different types of behavior, e.g., *A. atroparvus* Van Thiel hibernating in warm stables and houses occasionally biting, *A. messeae* Fall going into a state of more complete inactivity, etc. The hibernating behavior of the *Anopheles* in Korea seems to belong to the first category, i.e. some hibernating in warm stables and occasionally biting.

Survival tests were made with 499 *C. pipiens* caught from caves at Kimhae-kun near Pusan. When these mosquitoes were brought back to Pusan by car and then to Seoul by train, they were exposed to outdoor temperature (—6° to —9° C.) for 5–10 minutes and became completely inactive just like dead mosquitoes. However, they resumed activity soon after being kept in the train or room (10°–20° C.). Of 499 mosquitoes tested, 86 died in 24 hours and 55 in 48 hours after collection. Of 33 *A. sinensis* and *A. sineroides* tested, all died in 12 hours after collection. It seems that anophelines are less resistant to cold weather than *C. pipiens*.

MOISTURE AND FAT CONTENTS AND BODY WEIGHT OF ADULT *Culex pipiens* IN HIBERNATING CONDITION. It has been shown by several workers (Hackett (1), Roubaud and Colas-Belcour (7b), Swellengrebel (8), Swellengrebel and de Buck (9), etc.) that fat production in hibernating mosquitoes resulted from any combination of factors that tended to restrict the activity of the mosquitoes, and that the release from hibernating condition was caused by factors that tended to stimulate activity. Thus, fat production in wild mosquitoes in the fall was associated not only with a drop in temperature, but with the shortest period of evening twilight, with an appreciable shortening of the daylight, and with the onset of the fall rains, all of which would tend to keep the mosquito quiescent.

In order to show the variation of mosquito moisture and fat contents and body weight of adult *Culex pipiens* caught in hibernating condition and just before the release from hibernation, 1,100 *C. pipiens* adult females caught on 22 February in hibernating condition and 251 on 24 March, just before the release from the hibernation in the same culvert (about 300 meters long) at Susaek, Seoul, were tested. The Soxhlet extraction method with ether was applied for fat content, and the drying method at 105° C. was applied for the moisture content. The results are given in table 3.

There seems to be some difference between adult mosquitoes caught on 22 Feb. in hibernating condition and on 24 March just before release from hibernation. When mosquitoes came out of hibernating condition, fat and moisture contents and body weight decreased.

ATTEMPT TO ISOLATE JAPANESE B ENCEPHALITIS VIRUS FROM *C. pipiens* IN HIBERNATING CONDITION. The only vector from which Japanese B encephalitis virus

TABLE 3.—Moisture and fat content and body weight of *Culex pipiens*

Date	Number tested	Body weight (mg)*	Moisture content (%)	Fat content (%)	
				Wet base	Dry base
22 Feb. '60	1,100	4.76	69.35	6.43	20.87
24 Mar. '60	251	4.63	67.23	4.85	16.19

* Per adult.

has been repeatedly isolated by the various workers is *C. tritaeniorhynchus*. The first virus isolation from the mosquitoes was accomplished by means of mice inoculation by Mitamura (5), in 1938. Subsequently, Hammon *et al.* (2), reported the isolation of the virus from *C. tritaeniorhynchus* collected in Japan and in Guam, in 1948. In other countries, some workers have reported the isolation of the virus from other *Culex* species. Russian workers (6) state that the disease in the Maritime District is spread by *C. pipiens* and *C. tritaeniorhynchus,* but that certain other mosquitoes are also said to be involved.

Experimental transmission in the laboratory has been proved or claimed for a wide range of mosquitoes including *Anopheles, Culex,* and *Aedes. C. pipiens* appears to be one of the most generally common mosquitoes in Korea. Attempt was made to isolate the virus from *Culex pipiens* in hibernating condition.

Tests were done with 2947 *C. pipiens* adults, of which the majority was collected in the caves and culverts at the vicinity of Seoul in January to March and 436 were caught from the cave at Kimhae in December 1959. Fifty-eight groups (each group with 50 mosquitoes) were pooled. The results show that neither Japanese B encephalitis was isolated from the mosquitoes nor haemagglutination-inhibition antibody was present in the inoculated mice. The laboratory method for virus isolation is given below for ready reference.

Pools of 50 mosquitoes each were put in a mortar and ground thoroughly. One ml of 10 percent normal rabbit serum saline, containing 1000 units of penicillin and streptomycin per ml, was added by increments and the mixture ground again. Three ml of the same diluent were then added and mixed thoroughly by additional grinding. The suspension was then spun in a horizontal centrifuge at 1300 rpm for 20 minutes. The supernatant from this horizontal centrifugation was carefully removed and centrifuged at 15000 rpm for 20 minutes at a temperature of approximately 32° F. in the centrifuge chamber. This throws down large particulates including bacterial contamination and suspends fatty materials in a surface pellicle. The six suckling mice received the inoculation of 0.1 of the supernatant fluid by means of intracerebral route and after 10 days blind passage was carried out. After the second blind passage, all inoculated mice were bled and checked whether the haemagglutination-inhibition antibody was present or not.

Dissection of Mosquitoes. Salivary glands of 28 *A. sinensis* and 10 *A. sineroides* were dissected and all were negative for sporozoites. In January–March 1960 ovary dissection of 26 *A. sinensis,* 9 *A. sineroides,* 175 *C. pipiens* and 6 *C. orientalis* showed that all of them were nulliparous.

Larvae in Hibernating Condition. Some species of mosquitoes would pass the winter in the larval stage. During the hibernation, the phenomenon of cessation of growth in overwintering larvae is called "asthenobiosis." Roubaud and Colas-Belcour (7b) mentioned that the asthenobiosis was quite independent of external influences. Kobayashi (3) reported that most *Anopheles* larvae when found in November were on the point of dying and they almost all would die in the winter in Korea. And he stated that when mosquito larvae were found in early March or April they must have hatched out newly from eggs.

The present survey revealed that the last larvae found were 6 *A. sinensis* of the third instar in the paddies in Wondang, near Seoul on 5 November 1959. After the winter the first larvae of anophelines were collected from a ditch in the same area on April 10, 1960. During the winter season no mosquito larvae could be found in paddies, streams, pools, etc., which are usually their favorite breeding places. Also no larvae were discovered in the water or the mud under ice.

SUMMARY. *Anopheles sinensis, A sineroides, Culex pipiens,* and *Culex orientalis* hibernate in the adult stage. These anophelines hibernating in cow stables were all fed, showing that they could feed in winter. The most suitable places for the hibernation of *Culex pipiens* are culverts, and the next, caves.

The anophelines appear to be less resistant to low temperatures than the culicines.

Fat and moisture contents and body weight decreased in *C. pipens* just before their hibernation was over.

No Japanese B encephalitis virus was isolated from *Culex pipiens.*

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JUST PUBLISHED!
AMCA BULLETIN NO. 4
ORGANIZATION FOR MOSQUITO CONTROL

CERATOPOGONIDAE AS INTERMEDIATE HOSTS FOR *HAEMOPROTEUS* AND OTHER PARASITES[1]

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INTRODUCTION. Species of ceratopogonids are known hosts for a virus, protozoa and six filarioid nematodes belonging in four genera. In addition they are suspected vectors of other parasites and may be responsible for other diseases. This paper lists (Table 1) ceratopogonids known to transmit various parasites, summarizes work on the transmission of several of these, especially that on *Haemoproteus,* and reports observations relating to the feeding behaviour of some flies.

The adverse effects of bites of midges on man and the severe reaction to the bites of some species, such as *C. furens* (4), are well known. Damage to livestock is also reported (56). The status of some species of biting midges in causing disease or transmitting parasites is still somewhat uncertain (Table 1). There are reports of allergic dermatitis of horses caused by *C. robertsi* (51) in Australia. Arnaud (5) reports eczema in man in Japan caused by *C. erairai* and sores that are caused by the bites of *C. obsoletus* and that take 3–4 months to heal. *C. pifanoi, C. filariferus* and *Leptoconops mediterraneus* may be hosts for certain nematodes (28, 31, 42). However, microfilariae can be found in any blood-sucking ceratopogonid that feeds on a host carrying them in its blood. It does not follow that the microfilariae will complete their development and that the species of insect is a suitable host for the worms. Likewise, first stage larvae of filarioid nematodes may develop in insects that are not necessarily suitable hosts for them. However, as indicated below, several species of these helminths complete their development in ceratopogonids.

HOSTS FOR VIRUSES AND NEMATODES. DuToit's discovery (23) in South Africa of the transmission of the virus of blue-tongue disease by *Culicoides* opened a new field of investigation. The disease was found in sheep in Texas in 1948 (18). Price and Hardy (50) transmitted the virus to sheep by injecting them with a broth suspension of infected *Culicoides variipennis.* However, the epizootiology is still incompletely known, and, as Cox (18) points out, blue-tongue disease still presents a serious challenge to the livestock industry of the United States. Van Saceghen (55) and DuToit (23) believed the virus of African horse sickness is transmitted also by *Culicoides,* and Lewis (40) reported that the seasonal incidence of midges in the Sudan and the occurrence of the disease support this hypothesis. *Culicoides* possibly transmit other viruses also as Karstad *et al.* (36) isolated the virus of Eastern encephalitis from species collected in Georgia and refer to an isolation of Venezuelan equine encephalitis from similar insects.

Search for midges that are hosts of parasitic nematodes (Table 1) was stimulated by the discovery of Sharp (53) that *C. austeni* is a host and vector of *Dipetalonema perstans.* This filarioid of man occurs in Africa but has been reported also from British Guiana (27). Later Chardome and Peel (17) showed that a second species, *D. streptocerca,* would complete its development in *C. grahami,* which species they considered a less suitable host for *D. perstans.* Subsequently, differences of opinion arose concerning the relative importance of different species of *Culicoides* as vectors of these two nematodes. Henrard and Peel (30) said that *streptocerca* but

[1] Adapted from a paper given in the symposium on "Systematics, Biology and Economic Importance of Ceratopogonidae" at the Joint Meeting of The American and Canadian Entomological Societies held Dec. 2, 1959 at Detroit, Michigan.

TABLE 1.—Ceratopogonidae as Hosts for Parasites

Species*	Parasite or disease	Distribution	Host	References
C. palpidipennis	Blue tongue virus	*S. Africa	sheep	23
C. variipennis	Blue tongue virus	*Texas	sheep	50
C. nubeculosus	*Onchocerca cervicalis*	*England, Europe, Australia	horse	8, 24, 43, 54
C. pungens *C. oxystoma* *C. shortii* *C. orientalis*	*O. gibsoni*	*Malaya Australia India Africa	cattle, buffalo, zebu	7, 16, 32, 33
C. austeni *C. grahami* *C. inornatipennis*	*Dipetalonema perstans*	*Africa S. America	man	21, 22, 27, 32, 44, 45, 46, 53
C. grahami	*D. streptocerca*	*Africa	man, chimpanzee, gorilla	17, 30, 49
C. furens	*Mansonella ozzardi*	*S. America	man	14, 16, 27, 41
Culicoides nr. *piliferus*	*Haemoproteus nettionis*	*Canada	duck	26
C. sphagnumensis	*Haemoproteus canachites*	*Canada	spruce grouse	25
Forcipomyia velox	*Icosiella neglecta*	*France	frog	19
		More Uncertain Status		
C. mikarai	Fever	*Japan	man	37
C. erairai	Eczema	*Japan	man	5
C. robertsi	Allergic dermatitis	*Australia	horse	51
Culicoides sp.	Fowl pox	Asia	chicken	13
C. pifanoi	Microfilaria	*Venezuela	?	42
Leptoconops mediterraneus	Microfilaria	North Africa	mule	28
C. filariferus	1st stage larva (species unknown)	*Mexico	?	31
C. obsoletus	Cutaneous sores ?	*Japan	man	5
C. arakawae	*Leucocytozoon caulleryi*	*Japan	chicken	2
C. crepuscularis	*Haemoproteus sp.*	*Canada	crow ?	25
C. stilobezzioides	*Haemoproteus sp.*	*Canada	crow ?	25
C. stilobezzioides	*Haemoproteus sp.*	*Canada	purple finch	25
Culicoides spp.	Eastern encephalitis	*U. S. A.	?	36

* Distribution of some is limited and they are known hosts for parasites in certain countries only that are marked with an asterisk.

not *perstans* developed in *C. grahami* and they questioned whether Sharp had been working with *perstans*. However, Hopkins and Nicholas (32) confirmed Sharp's results but stated that *C. grahami* may be a less suitable vector than *C. austeni* except in places where *grahami* is the more abundant species. Nicholas and Kershaw (45) concluded that the occurrence of fewer larvae of *D. perstans* in *C. grahami* than in *C. austeni* indicated that fewer survived rather than that fewer were ingested. Duke (22) claimed that few larvae of *perstans* reach the infective stage in *grahami* but many do so in *C. inornatipennis*. He also confirmed (21) the work of Chardome and Peel. He thought the failure of others to observe development of *streptocerca* in *grahami* might have resulted from the examination of flies that had fed on *streptocerca*-free areas of the skin. Possibly these worms are transmitted also by other species of *Culicoides* as several are known to feed on man in localities where the worms occur (44, 46, 47).

In 1933 Steward (54) showed that *Onchocerca cervicalis* is transmitted to horses in England by *C. nubeculosus*. This worm occurs also in Australia, Europe and Asia (8, 24, 43, 51) but the vectors in some

localities are unknown. Molev (43) reports 14 species of *Culicoides* in parts of Russia where the worm is present. Buckley (16) showed that another species, *O. gibsoni* in cattle, developed in four species of *Culicoides* in Malaya. The parasite is reported from several other places as well (7, 34, 52) but the vectors in these countries are unknown. The possibility of *Culicoides* being a host for a third species, *O. volvulus,* was investigated by Gibson and Ascoli (29). They found one of 47 specimens of *C. guttatus* infected with *O. volvulus* in Guatemala but as the species was rare they considered it unimportant in the spread of the parasite.

Culicoides furens was shown by Buckley (14, 15) to be a vector of another nematode, *Mansonella ozzardi,* that occurs in South America (27, 41). Perhaps other *Culicoides* transmit this worm also as it is reported from British Guiana from places where *C. furens* is rare but where *C. paraensis* is common.

In addition to these five species of nematodes that develop in *Culicoides* a sixth, *Icosiella neglecta* of frogs, is transmitted by *Forcipomyia velox* (19). Scores of other filarioid nematodes occur in various hosts throughout the world yet the mode of transmission is known for a few only. Most probably species of ceratopogonids will prove to be vectors of some of them.*

Hosts for Protozoa. Recently, species of *Culicoides* showing ornithophilic behaviour have been shown to be hosts for *Haemoproteus* (25, 26). This has raised interesting questions concerning transmission of these parasitic protozoa and the feeding behaviour and other characteristics of *Culicoides* that are known hosts. Consequently, most of the remainder of this paper will summarize work which has shown that a species of *Culicoides* near *piliferus* and *C. sphagnumensis* are hosts for the species of *Haemoproteus* occurring in ducks (*Anas boschas*) and spruce grouse (*Canachites canadensis*) respectively.

Reports by Adie (1), O'Roke (48) and Baker (6) led us to suspect that species of Hippoboscidae were feeding on ducks and serving as hosts for *Haemoproteus nettionis* that was commonly found in them. While working on blood protozoa in ducks in Algonquin Park it was noted that most of our ducks placed outdoors on the lakeshore during June and July became infected with *H. nettionis.* Anderson, therefore, in 1955 (3) examined many of these ducks daily for several weeks during the summer. Hippoboscids were not recovered from them. This was not unexpected as Bequaert (9), following extensive work, stated that ducks are unsuitable hosts for these insects. The common insects feeding on the ducks during this time were simuliids and biting midges.

A series of observations and experiments were designed, therefore, to determine whether *Culicoides* and/or simuliids serve as intermediate hosts for *H. nettionis* of ducks. Four ducks were placed out of doors from 9.00 p.m. to 3.00 a.m. E.S.T. for seven days and from 9.00 p.m. to 12.00 midnight for an additional three weeks. (There is no evidence that blackflies are flying during these hours of the night.) All four ducks became infected with *Haemoproteus* indicating that transmission occurred at night; none became infected with *Leucocytozoon,* which is transmitted by blackflies. Two ducks left out of doors continuously during the same period became infected with *Leucocytozoon* and *Haemoproteus.*

During this same period specimens of *Culicoides* that fed on infected ducks were held in captivity, later macerated in saline and injected into 12 ducks. Infections were produced in nine which received suspensions of these flies, proving that *Culicoides* is a suitable host for *H. nettionis* of ducks (26). The cycle of development within *Culicoides* was investigated by collecting them following their engorgement on infected ducks, maintaining these midges in captivity, dissecting and sectioning them at intervals thereafter and examining the

* Mr. C. Hibbler, Colorado State University reported recently to the Midwest Fish and Wildlife Conference that species of *Culicoides* are intermediate hosts for species of *Splendidofilaria* in *Pica hudsonia.*

preparations for stages of development of the parasite. Thus various stages in the sexual cycle were demonstrated and the final stage—the sporozoite—was found in the salivary glands of specimens of *Culicoides*.

Using similar methods it was shown (25), during the summer of 1959, that *C. sphagnumensis* is a suitable host for a species of *Haemoproteus* occurring in the spruce grouse.

Sporozoites of *Haemoproteus* were seen also in the salivary glands of specimens of *C. crepuscularis* and *C. sphagnumensis* that were dissected 8 or more days after they had fed on crows (*Corvus brachyrynchos*) infected with this parasite. Sporozoites were found also in glands of *C. stilobezzioides* that had fed on an infected purple finch (*Carpodacus purpureus*) and in *C. crepuscularis* and *C. sphagnumensis* that had fed on infected white-throated sparrows (*Zonotrichia albicollis*). Although this does not establish that these midges are vectors of these particular parasites they are obviously suitable hosts for some species. The pattern of sexual development observed for two species of *Haemoproteus* in *Culicoides* is illustrated in Fig. 1.

Further indication that *Culicoides* rather than species of Hippoboscidae are responsible for the transmission of other species of *Haemoproteus* was obtained from comparisons of the infections in miscellaneous birds with the number of blood-sucking insects feeding on them. A measure of the abundance of *Culicoides* was obtained by collecting engorged specimens of them at different times during the summer, from selected birds which included ducks (Anatidae), grouse (Tetraonidae), robins (Turdidae), purple finches (Fringillidae), woodpeckers (Picidae), and white-throated sparrows (Fringillidae). Presumably the number of *Culicoides* recovered from these birds indicates the trend in the number of ornithophilic midges present throughout the season. The estimate of the abundance of hippoboscids was obtained from the actual number of these insects obtained from the birds examined.

The results (12) clearly indicated a high incidence with *Haemoproteus* in many birds and the presence of many with high parasitaemias before hippoboscids were recovered, and at the time *Culicoides* were abundant. Consequently, from the results of these various observations and experiments it is concluded that species of *Culicoides* will be shown to be vectors of all species of *Haemoproteus* occurring in Algonquin Park.

Dr. Jörg (35), who is working on the transmission of *Haemoproteus* in Argentina, notes the abundance of *Culicoides* in parts of that country. He found that parasite-free young magpies did not become infected with *Haemoproteus* if taken outside the area where *Culicoides* occurred, although these birds were exposed to other blood-sucking insects.

The situation may differ elsewhere. In New Zealand, for example, ceratopogonids are present but there is no record of *Culicoides*, and *Haemoproteus* is known to occur (38). However, Mr. Downes (20) has pointed out to us that *Leptoconops*, a related genus, is present. Further work on ceratopogonids in New Zealand, using collecting techniques similar to those employed here (10), may reveal *Culicoides* and other related genera. Dr. Lee in a personal communication (39) states ". . . the ecological niche into which *C. austropalpis* fits (in Australia) may well have its counterpart in New Zealand."

Brief reference should be made to another avian protozoan parasite—a trypanosome—that is common in many birds. Developing stages of trypanosomes have been observed in specimens of *Culicoides* that fed on birds infected with these parasites. Bennett (11) has transmitted one of these trypanosomes by injecting a bird with a suspension of specimens of *Culicoides* carrying the developing stages of the parasite. Other evidence (11) suggests, however, that *Culicoides* is not the important vector in this locality although elsewhere this possibility should be kept in mind.

Biting midges may be hosts for other parasitic protozoa also, as Akiba (2) re-

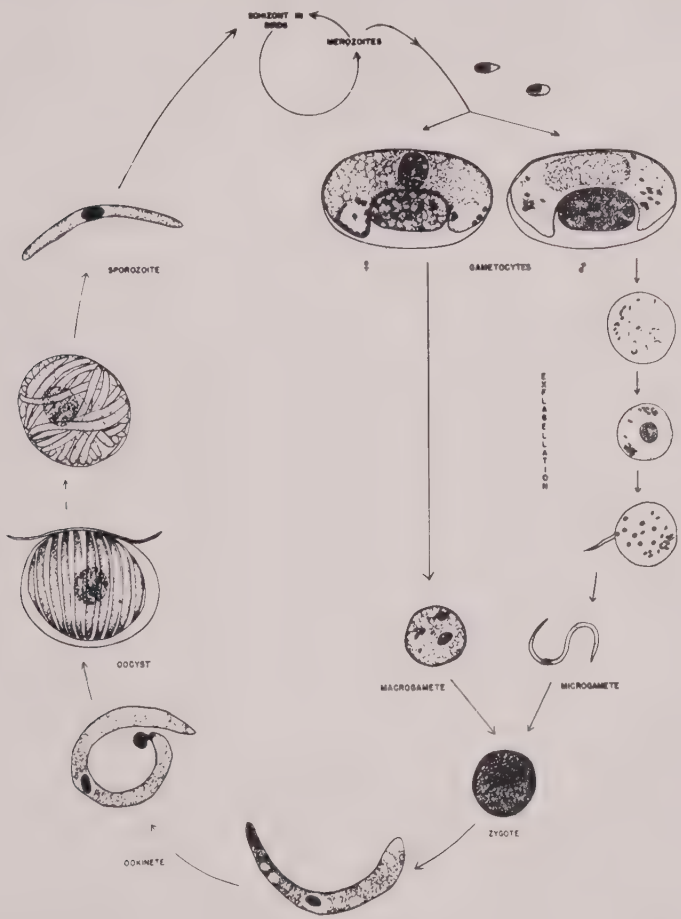

Fig. 1.—Composite diagram illustrating the sporogonic cycle of *Haemoproteus* in *Culicoides*.

ported recently sporogony of *Leucocytozoon caulleryi* in *Culicoides arakawae*.

Comments on Feeding Behaviour. Limited comparisons of the number and kinds of *Culicoides* feeding on different birds in two habitats are available from data reported elsewhere (10). These data (Tables 2, 3) were compiled from collections of *Culicoides* made from ducks, grouse, crows, an owl and flickers, that were exposed by the lake-shore, on the ground at the edge of second growth boreal forest, and suspended 5–15 feet in the air at the edge of these woods.

The collections showed that *C. sphagnumensis, stilobezzioides, crepuscularis, haematopotus,* a species near *piliferus,* and *obsoletus* fed on some or all of the birds. Relatively few *obsoletus* were taken on birds, although at times, it was extremely abundant, fed commonly on man, and thousands could be swept in a net. On the other hand thousands of the species near *piliferus* were taken from ducks and large

TABLE 2.—Number and species of *Culicoides* collected after feeding on different birds at different times

	5–7 p.m.	7–9 p.m	9–11 p.m. E.S.T.	Grouse	Crow	Duck	Owl	Flicker
No. collections	168	111	20	66	60	122	13	7
C. sphagnumensis	28	688	383	38	878	0	10	92
C. stilobezzioides	11	64	39	22	43	0	6	14
C. crepuscularis	0	23	14	10	43	0	2	1
C. obsoletus	1	27	5	0	0	0	0	0
C. haematopotus	0	2	3	0	9	0	0	0
C. nr. *piliferus*	15	hundreds	hundreds	0	0	hundreds	0	0
Undetermined	160	580	0	0	0	0	0	0

TABLE 3.—Number and species of *Culicoides* collected from crow exposed in boreal forest and from miscellaneous birds exposed in the forest and at a lakeshore

	Collections from crow				Collections from miscellaneous birds		
	Boreal forest				Lake shore ground	Boreal forest	
Habitat	Ground	5′ in air	10′	15′		Ground	5′–25′ in air
No. collections	4	4	4	4	119	46	150
C sphagnumensis	24	280	360	160	0	26	1160
C. stilobezzioides	1	16	21	18	0	2	124
C. crepuscularis	5	5	6	7	0	5	61
C. obsoletus	0	0	4	5	22	0	11
C. haematopotus	1	1	0	3	0	1	8
C. nr. *piliferus*	0	0	0	0	hundreds	6	7

numbers of other species from other birds, but none of these were taken from man. *C. stilobezzioides, sphagnumensis, crepuscularis* and the species near *piliferus* are clearly ornithophilic. It is not surprising, therefore, that some are involved in the transmission of *Haemoproteus*. The species of *Culicoides* near *piliferus* was taken most frequently from ducks and by the lakeshore.

C. sphagnumensis, stilobezzioides and *crepuscularis* were taken more commonly from woodland types of birds and at elevations of 5′ to 15′ from the ground in the forest rather than at the forest floor. Large numbers of these ornithophilic species were obtained only by exposing birds in the tree tops and collecting the flies feeding on them. *C. sphagnumensis* seemed to feed more commonly on grouse and crows than on the passerine birds and *stilobezzioides* and *crepuscularis* were often on the latter. *C. obsoletus,* under certain conditions, fed during the day as well as at night. *C. crepuscularis, sphagnumensis* and *stilobezzioides* fed at dusk although on several occasions they were collected one or two hours later. The species near *piliferus* began to feed about the same time but many individuals have been collected throughout the night. *Forcipomyia velox* on the other hand is reported by Desportes (19) to feed on frogs during the day rather than at night. It was noticed also that ornithophilic species continue to feed when the air temperature drops to 50–55° F.

These limited observations on collections of *Culicoides* from different birds in different habitats indicate that the feeding behaviour of these insects may affect noticeably the incidence of infection with particular parasites in different animals.

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ATTACK RATE OF *CULEX TARSALIS* ON REPTILES, AMPHIBIANS AND SMALL MAMMALS [1]

B. E. Henderson [2] and L. Senior [2]

Thomas and co-authors (1) recently suggested that cold-blooded vertebrates may play a role in the overwintering and summer maintenance of western equine encephalitis (WEE) virus. Previous studies (2–7) have indicated that a variety of small mammals may also play some part in the maintenance of WEE and St. Louis encephalitis (SLE) viruses in nature. One obvious measure of the relative importance of these animals to the ecology of the viruses is the degree to which *Culex tarsalis,* the primary arthropod vector of these viruses in the Western United States, is attracted to and feeds on the various animal species. Dow, and co-authors (8) reported limited attractiveness for *C. tarsalis* of a small number of small mammals and cold-blooded vertebrates. The objective of this study was to extend these observations.

Methods. Poso Creek, a small stream about 12 miles N.E. of Bakersfield, was the area selected for field exposures of animals. A 350-yard stretch of the stream bank was selected for the experiment. In this area the stream, which is a drainage channel for clarified effluent from oil wells in the vicinity, has a moderately rapid central channel with a thick marginal growth of tules. There are numerous pools along the margin with emergent grasses which serve as excellent breeding places for culicine mosquitoes. Along the edge of these shallow waters there is a series of small cottonwood trees. Ten trap stations were located on the limbs of these trees, three in crotches of large shrubs and one in a dense cluster of tules.

The animals were collected locally, and each was exposed for one night in a small portable bait can trap described by Dow and co-authors (8). Insofar as possible, each animal was restrained, either within a nylon stocking or in small cages, before being placed in the trap. The baited traps were placed in the field in the later afternoon with the funnels oriented in line with prevailing air movements. The following morning the ends of the traps were plugged and the animals removed through the traps' sleeve opening. The bait cans were then taken to the field laboratory where the mosquitoes were chloroformed, identified, and their state of blood engorgement recorded.

Three different sets of controls were established. Prior to any animal exposures, traps containing 3 pound blocks of dry ice were placed overnight in 6 out of 14 sites to be used for the animal tests. The purpose of this run was to establish that there was a sufficient population of mosquitoes for the study, and to provide a base line measure of the variability of individual sites.

Two unbaited traps were included each test night with the animal exposures since it was observed early in the experiment that the smallest lizards attracted so few mosquitoes that some measure was needed of the chance entry of mosquitoes into traps.

As a third comparison, two 8-week-old leghorn chickens were exposed each night that other animals were exposed. These chickens were restrained in nylon stockings and placed in stations located at the upper and lower ends of the trapping-line.

The results of the dry ice run (Table 1) established the presence of a significant population of *C. tarsalis* in the Poso Creek

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TABLE 1.—Mosquitoes collected in 6 traps baited with dry ice, Kern County, 1960

Station	Total all species	Number of each species collected		
		Culex tarsalis	*Culex erythrothorax*	*Anopheles franciscanus*
1	409	402	5	2
2	267	246	21	1
3	962	887	72	3
4	632	485	141	6
5	389	364	22	3
6	236	194	33	9

area. As the different stations showed a nearly four-fold variation between the highest and the lowest numbers of trapped mosquitoes, the test animals were randomly placed in the different stations and, whenever enough animals of the different species were available, representatives of each species were exposed each night.

RESULTS AND DISCUSSION. A total of 88 animals representing 16 different species was exposed; 45 were reptiles (7 species), 17 were amphibians (2 species), and 26 were small mammals (7 species). Table 2 presents the mosquito collections obtained from the field exposures of these animals as well as for the control chickens and the unbaited traps. Every species attracted some *C. tarsalis;* some of the larger rodents attracted numbers similar to the chickens while the smaller lizards attracted an average of only one or two mosquitoes per night. The animals in each group are ordered according to their approximate average size and weight; thus, *Citellus beecheyi,* the largest of the mammals tested, is listed first in the mammal group. There is a fairly good correlation between the average number of mosquitoes attracted and

TABLE 2.—*Culex tarsalis* collected in traps baited with small mammals, reptiles, and amphibians as compared with chicken and unbaited trap controls, Kern County, 1960

Species	No of times species was exposed	Number collected	
		Average per run	Maximum and minimum in all runs
Mammals			
Citellus beecheyi (Beechey Ground Squirrel)	2	159.0	177–141
Citellus nelsoni (San Joaquin Antelope Squirrel)	2	153.0	193–111
Dipodomys heermanni (Heermann Kangaroo Rat)	8	65.1	103– 39
Dipodomys nitratoides (San Joaquin Kangaroo Rat)	4	50.5	89– 27
Peromyscus maniculatus (Deer Mouse)	6	53.3	109– 31
Perognathus inornatus (San Joaquin Pocket Mouse)	1	38.0	38
Mus musculus (House Mouse)	3	17.6	28– 5
Reptiles			
Coluber flagellum (Red Racer)	1	25.0	25
Lampropeltis getulus (King Snake)	1	8.0	8
Crotaphytus wislizenii (Leopard Lizard)	14	8.9	39– 0
Sceloporus occidentalis (Western Fence Lizard)	6	2.6	11– 0
Phrynosoma spp. (Horned Lizard)	9	1.8	8– 0
Cnemidophorus tigris (Western Whiptail)	11	0.5	4– 0
Uta stansburiana (Side-blotched Lizard)	3	1.7	5– 0
Amphibians			
Rana catesbeiana (Bullfrog)	7	28.0	65– 0
Bufo boreas (Western Toad)	10	15.4	64– 0
Chickens	15	214.0	496– 72
Unbaited traps	10	0.5	2– 0

the size of the animals within each group of animals tested; the larger lizards, such as *Crotaphytus wislizenii,* attracted four or more times as many mosquitoes as the smaller lizards, such as *Uta stansburiana.*

On the average the mammals were about five times as attractive to *C. tarsalis* as the cold-blooded vertebrates. *Rana catesbeiana* is about the same size as the large ground squirrel, *C. beecheyi,* while the smallest mouse, *Mus musculus,* is comparable in size and weight to *Sceloporus occidentalis* or *U. stansburiana.*

Table 3 presents the rates of engorgement of the attracted mosquitoes on each species. Of special significance is the rather consistently high percentage of feedings on reptiles which compares very closely to that on the chicken controls. While the chickens and reptiles were very easily restrained in nylon stockings, effective restraint of the mammals and amphibians was more difficult. Partly because of this, most of the mamals and amphibians had a lower engorgement rate in the mosquitoes they attracted; in fact, for survival of *Perognathus inornatus* and *Peromyscus maniculatus,* it was necessary to allow the animals considerable freedom in a wire mesh cage, and thus the mosquitoes probably had difficulty in feeding. When the mammals were well restrained, as in the case of *Citellus nelsoni,* the engorgement rate was comparable to that on the chicken controls, and this suggests that feeding would have been more frequent on the other mammals with adequate restraint. Although the amphibian group was not very well restrained, engorgement rates on these hosts were so low that there may have been a repellent factor which limited feeding. On at least two occasions, amphibians were restrained quite well and there was less than 25 percent engorgement.

The animals tested normally are terrestrial or aquatic and would not be exposed to mosquitoes in trees or shrubs and above ground level. It was impractical to attempt exposures in the normal noc-

TABLE 3.—Comparative engorgement rates of *C. tarsalis* mosquitoes collected by exposure of experimental hosts and comparison group, Kern County, 1960

Species	Total Number		Percent of attracted engorged
	Collected	Blood engorged	
Mammals			
Citellus beecheyi (Beechey Ground Squirrel)	318	161	50
Citellus nelsoni (San Joaquin Antelope Squirrel)	306	253	83
Dipodomys heermanni (Heermann Kangaroo Rat)	520	326	63
Dipodomys nitratoides (San Joaquin Kangaroo Rat)	202	98	49
Peromyscus maniculatus (Deer Mouse)	320	20*	6*
Perognathus inornatus (San Joaquin Mouse)	38	0*	0
Mus musculus (House Mouse)	52	38	73
Reptiles			
Coluber flagellum (Red Racer)	25	23	92
Lampropeltis getulus (King Snake)	8	2	25
Crotaphytus wislizenii (Leopard Lizard)	120	108	90
Sceloporus occidentalis (Western Fence Lizard)	16	14	87
Phrynosoma spp. (Horned Lizard)	16	12	75
Cnemidophorus tigris (Western Whiptail)	6	4	67
Uta stansburiana (Side-blotched Lizard)	5	4	80
Amphibians			
Rana catesbeiana (Bullfrog)	196	47	25
Bufo boreas (Western Toad)	154	9	6
Chickens	3214	2957	92
Unbaited traps	5	0	0

* Very poor restraint of host may have influenced opportunity for feeding.

The animals tested normally are terrestrial or aquatic and would not be exposed to mosquitoes in trees or shrubs and above ground level. It was impractical to attempt exposures in the normal noc-

turnal habitats of these animals and the results probably are not a measure of their usual contact with vectors. It is suspected that the methods and locations of these tests increased exposure to vector attack.

Only *C. tarsalis* is referred to in the data presented in Tables 2 and 3. This species was the most abundant with all baits, and in the series of animal exposures it often was the only mosquito attracted. *Culex erythrothorax* was attracted in small numbers and fed on chickens, *Citellus beecheyi, Citellus nelsoni, Dipodomys heermanni, Dipodomys nitratoides, Peromyscus maniculatus, Mus musculus,* and *Sceloporus occidentalis*. This mosquito also was attracted to but did not feed on *Rana catesbeiana* and *Bufo boreas.*

These observations extend the known range of host species attractive to and fed on by *C. tarsalis*. The relatively low attractiveness of the several species of reptiles and amphibia, would indicate that they are less likely to serve as effective natural hosts of WEE and SLE viruses and sources of vector infection than are warm blooded hosts.

SUMMARY. *Culex tarsalis* was attracted to mosquito traps baited with 7 species of rodents, 7 species of reptiles and 2 species of amphibians. The number of *C. tarsalis* attracted was proportional to the size of the hosts within each major group. Rodents were more attractive than reptiles or amphibians, but less so than 8-week-old chickens or dry ice. A high proportion of mosquitoes fed on most hosts if the animals were adequately immobilized.

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OBSERVATIONS ON MOSQUITO FEEDING ACTIVITY ON THE FLOWER HEADS OF *EUPATORIUM* AND *SOLIDAGO* (COMPOSITAE)

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As pointed out by Bates (1949), it is assumed that in nature plant juices, particularly flowers, form the principal food of male mosquitoes and of females of species not known to suck blood. Early records of mosquitoes as flower visitors are summarized by Howard, Dyar, and Knab (1912). Subsequent records, e.g., Britten (1937) and Philip (1943), add little to the general fact that mosquitoes of both sexes

Fig. 1—Upper portion—male *Aedes vexans,* proboscis extended, on a flower head of *Solidago*; lower portion—stand of *Eupatorium* (note embayment of Wheeler Reservoir). Photo by P. K. Anderson.

are fairly frequently found at flowers. Although general statements on this subject are traditional in mosquito literature, reports of actual observation are scant.

The purpose of this paper is to report recent observations on important mosquito species visiting the flower heads of *Eupatorium* and *Solidago*. This activity was observed from late August through September, 1960, in the Flint Creek area of Wheeler Reservoir near Decatur, Alabama.

On August 30, a male specimen of

Psorophora cyanescens was discovered feeding on a flower head of *Eupatorium serotinum*. Since *P. cyanescens* is a viciously biting floodwater mosquito and *Eupatorium* is quite common in low areas of the Tennessee Valley, followup observations were made on the association. The following day, 26 mosquito specimens, including both males and females, were collected after being observed to feed on *Eupatorium* flower heads. The collections, taken from three different localities in the Flint Creek area of Wheeler Reservoir, yielded four floodwater species: (*Psorophora cyanescens* —2 females; *P. ferox*—2 males, 13 females; *P. ciliata*—1 male; *Aedes trivittatus*—4 males, 4 females).

Casual observations continued through September, and on the 28th a great amount of mosquito feeding was found on the flower heads of goldenrod, *Solidago altissima*. This collection yielded 15 specimens (12 males, 3 females) of *Aedes vexans,* the most abundant floodwater pest species in the Tennessee Valley. Also collected on this date were 12 specimens of *P. ferox* (9 males, 3 females) and 19 specimens of *Ae. trivittatus* (10 males, 9 females).

All of the foregoing observations and collections were made in the morning hours (9–11 a.m.) during the course of other routine mosquito inspections in the area. Mosquito activity was seemingly confined to shaded stands of *Eupatorium* and/or *Solidago* at a woodland-open field ecotone on bright, sunny days, but was observed on an overcast day in a stand of *Solidago* along a fence row dividing two open fields.

Evidence indicates that some of the male specimens of *Ae. vexans* were freshly emerged in that their bodies were yet soft and moist, the genitalia had not rotated, and pigmentation had not fully darkened. This implies that the flower heads of goldenrod, in this instance, were the very first food source for the specimens.

It is to be noted that representative specimens of all of the species herein mentioned were observed to assume characteristic feeding positions preceded by probing action. The specimens exhibited persistence in their activity to the point that they were not easily disturbed even by the handling of flower heads during photography. Despite the fact that the females of all of these mosquito species are fierce biters of man, they showed no inclination to forsake the flower heads in favor of the human blood source during collections.

The upper portion of figure 1 shows a male specimen of *Ae. vexans,* with proboscis extended, on a flower head of *Solidago;* the lower portion shows a stand of *Eupatorium* with a small embayment of Wheeler Reservoir in the background.

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A MOBILE TRAP FOR STUDYING THE BEHAVIOR OF FLYING BLOODSUCKING INSECTS

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In studying populations of flying bloodsucking insects, there is often a need to determine a number of behavioral characteristics. Conventional light traps are rather limited in usefulness, since they attract large numbers of unwanted species of insects. Light traps also require a power source, and therefore cannot be used readily in remote areas.

The trap herein described was developed for maximum versatility within a single unit. It serves as a practical research tool for studying activity periods, with the potential use of several different attractants. Usually a single attractant is tested at any one time, but the nature of the construction permits comparing attraction to an animal host with light or moving visual pattern. The attractants and interval collection principle have been described by others; this trap simply incorporates these methods into a single unit. The arrangement shown can be modified further at the discretion of the investigator.

Although this device was developed for sampling mosquitoes, it also captured ceratopogonids and simuliids. Of course, the light trap portion is attractive to a great variety of insects, and the substitution of various types of odor attractants should collect insects of many different kinds. For example, the use of fruit fly attractants in the animal host portion should permit an analysis of activity periods in these insects.

The following desirable characteristics were incorporated: (1) Mobility through being mounted on a trailer and having a source of electricity. (2) A variety of attractants, i.e. light, moving visual pattern, and a choice of host animals. (3) Interval collections into separate chambers permitting the determination of activity periods. (4) The use of trap cage chambers rather than killing jars, yielding a substantial proportion of live catches for virus determination or other studies requiring living insects. (5) A rotating turntable feature which permits an analysis of the comparative attractiveness of various hosts.

Description. The base of the unit is a two-wheeled trailer (Fig. 1, 3). The essential feature of timed interval operation is a rotating turret, in this instance obtained from a surplus bomber training turret (Fig. 3a). Trap chambers can be attached to the rotating turret for timed interval trapping (Fig. 1), or modified stable traps can be hung by brackets to test animal host preference on a turntable basis (Fig. 3).

The rotating visual pattern (Figs. 1, 3, b) largely follows the design described by Haufe and Burgess (1960). It is rotated by a motor and reduction gear turning a pulley, attached in back of the control panel and therefore not visible in the accompanying illustrations. The actuated pulley connects to a pulley at the base of the rotating striped column by means of a belt, causing the drum to rotate. The speed of the striped column can be varied by changing the size of the pulley connected to the reduction gear. A space at the top of the rotating column permits entrance of insects attracted to that region by the moving visual pattern, and an internal fan pulls them down through a screen funnel where they are ejected into a trap chamber.

The attractant for light trapping is an ordinary 60 watt incandescent bulb. It is mounted within the top of the visual pattern column, and can be made more readily visible by removal of a six-inch upper portion of the striped pattern. Hardware cloth of one-half-inch mesh, lying just

[1] Associate Entomologist, Washington State University. This study was supported by a grant (E-2253) from the National Institutes of Health, U. S. Public Health Service. Washington Agricultural Experiment Stations Scientific Paper 2072. Work was conducted under Project 1434.

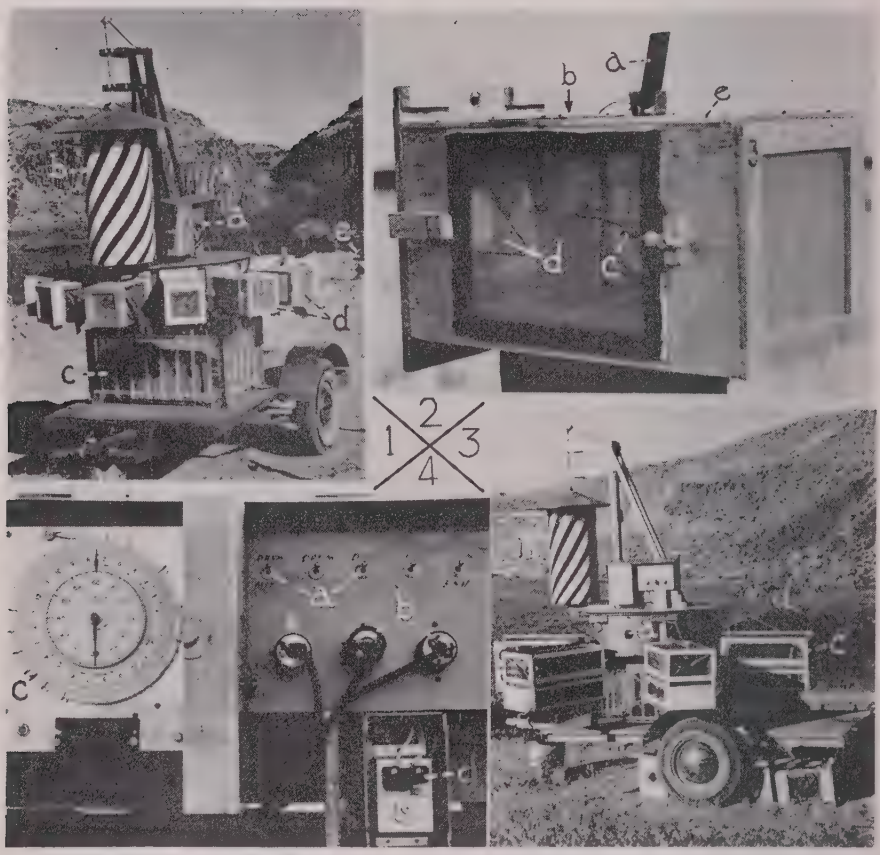

FIG. 1.—General view of trap with timed-interval chambers attached. a. Control panel. b. Striped cylinder providing moving visual pattern. c. Chamber serving as base and containing host animals. d. Timed interval trap chambers. e. Generator for supplying electrical power.

FIG. 2.—Detail of timed-interval trap chamber (9 x 9 x 18″). a. Lever with string attached to weighted closure arm. b. Point of entrance into metal cone in top of chamber. c. Weighted closure arm. d. Screen cone through which insects attracted to animal host are blown. e. Clear plastic top of chamber, admitting maximum light.

FIG. 3.—General view of trap with modified stable-type traps for studying host preference. a. One of twelve holes in turret, on which timed-interval traps are based and through which insects attracted to animal host are blown when trap is in operation as in Fig. 1. b. Striped cylinder providing moving visual pattern. c. Modified stable-type trap with entrance baffle on sides. d. Bracket supporting modified stable-type trap.

FIG. 4.—Detail of control panel. a. Switches for controlling various trapping methods. b. Plug connectors to motors and lights. c. Program timer for controlling interval trapping. d. Intermittent event timer which operates blower at top of animal host chamber.

beneath this removable section, prevents moths and other large insects from being trapped. In principle this operates much like the New Jersey type of mosquito trap, but it empties into a chamber instead of a killing jar. It is also possible to test the combined attractiveness of rotating column and light.

Animal attraction for timed interval evaluation operates on the principles of the trap described by Lumsden (1958). The main chamber containing an animal host is constructed with an angle iron frame, and is sturdy enough to support the heavy upper portion of the trap. Its sides consist of plexiglass panels with one-centimeter spacings. In tests thus far, the host animals are centered in the main chamber within a cage, and this is covered with mosquito netting to prevent mosquitoes from actually feeding. The top of the entrance chamber is solid except for a circular opening containing a powerful fan. The fan sucks air through this chamber and blows it into a screen funnel which empties against the inner face of the rotating main drum. This screen funnel is directed to the side of the drum opposite the location of the moving visual pattern and light trap, and when properly aligned it channels insects through a hole in the drum (Fig. 3a) and into a trap chamber (Fig. 2d). An intermittent event timer (Fig. 4d) is set in these studies to turn the fan alternately on for two minutes and off for four minutes.

Twelve trap chambers (Fig. 1d, 2) receive the insects trapped by attraction to moving visual pattern, light, or animal host. The insects captured while attempting to bite an animal host enter a trap chamber by a screen cone (Fig. 2d). Insects trapped at light or by visual pattern enter the top of a trap chamber through a sheet metal funnel (Fig. 2b). A simple screen cone is unsatisfactory because it plugs up with the enormous numbers of chironomids which are often trapped when light is used as an attractant. When not in the trapping position, the bottom of the metal funnel is forcibly closed by a hinged, counterweighted lid (Fig. 2c). When in the trapping position the counterweight arm is lifted by a string attached to a lever on top of the cage (Fig. 2a). The lever is held in the open position by a removable arm from the main trap frame. During a trapping period insects are prevented from escaping by the entering stream of air from the fan within the rotating column. A cloth sleeve permits the aspiration of trapped insects. The plexiglass top of each trap chamber permits entrance of light for better visibility during aspiration of insects. A lug on the revolving drum strikes a cutoff microswitch on the frame and stops each chamber in the correct position. The next chamber is brought into position when the timer (Fig. 4c) actuates the motor which turns the revolving drum.

The turntable method of determining host selection (Dow, 1959) is also incorporated. To achieve this, the trap chambers are removed and six brackets (Fig. 3d) are bolted to the turret. Small, modified stable traps with entrance baffles are hung on the brackets (Fig. 3c). The trapped insects can be aspirated through a cloth sleeve on the outside end. A circuit to bypass the microswitch which stops the turret at the next trap chamber permits constant rotation. The motor and reduction gear rotate the turret once every four minutes.

Electricity is required to operate the various features of this trap. A surplus Army Signal Corps generator supplies this when it is otherwise unavailable (Fig. 1e). The generator can be bolted to the back of the trailer bed when moving, but it is set at least fifty feet away during operation so as not to influence attractiveness unduly. A timer is mounted on the generator to ground it out at a predetermined time, thus eliminating the necessity for an operator to be at hand the moment a run is completed.

A number of switches are incorporated to operate the trap, and these are centered on a control panel (Fig. 4). A Zenith program timer (model P5–24 Precision Equipment Company, 4403 Ravenswood Avenue, Chicago 40, Illinois) has

been most useful because a twenty-four hour cycle can be programmed with divisions down to five-minute intervals. The control panel holds a main cutoff switch, and separate switches are required to operate the turret, to bypass the turret cutoff microswitch, to turn the revolving visual column, to turn on the light, and to operate the cyclic fan connected to the animal host chamber.

DISCUSSION. This trap has been under development for two years, and has been operated for two summers in the Columbia Wildlife Refuge, U. S. Fish and Wildlife Service, near Othello, Washington. It has thus been possible to study the behavior of mosquitoes in remote areas of the refuge where electricity is not available.

Attraction to light and/or moving visual pattern can be compared with the attractiveness of animal hosts. Since both attractants are in rather close proximity, it cannot be stated that they do not influence each other. However, a comparison of tables 1 and 2 indicates that animal host attraction may be more constant than that of light, and may circumvent the cyclic effectiveness of light traps which coincides with the cyclic competition of moonlight referred to by Pratt (1948) and Provost (1959). This trap is being used for further studies on the behavior of mosquitoes, particularly *Culex tarsalis*.

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TABLE 1.—Comparison of light versus animal host for trapping mosquitoes

Othello, Washington 12–13 July 60 (Full Moon 8 July)

	C. tarsalis				*A. freeborni*			
	3 chickens		light		3 chickens		light	
Time	♀	♂	♀	♂	♀	♂	♀	♂
18.00	0	0	2	0	0	0	0	0
20.00	32	0	4	0	44	0	4	0
22.00	14	0	4	2	15	0	0	0
24.00	12	0	4	0	20	0	6	0
2.00	13	0	4	0	81	0	6	0
4.00	1	0	0	0	14	0	0	0
Total	72	0	18	2	174	0	16	0

TABLE 2.—Comparison of light versus animal host for trapping mosquitoes

Othello, Washington 25–26 July 60 (New Moon 23 July)

	C. tarsalis				*A. freeborni*			
	3 chickens		light		3 chickens		light	
Time	♀	♂	♀	♂	♀	♂	♀	♂
19.00	2	0	1	0	2	0	0	0
20.00	62	4	74	135	9	0	3	1
22.00	41	4	36	58	2	2	0	2
24.00	37	2	28	56	7	1	1	3
2.00	44	3	21	41	3	3	7	5
4.00	2	0	1	0	1	0	2	0
Total	188	13	161	290	24	6	13	11

developed some of the modifications of the trap chambers. Mr. Paul Steel, manager of the Columbia Wildlife Refuge, U.S.F.W.S., has been most gracious in aiding studies on biting insects within the refuge.

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MOSQUITO CONTROL IN OLIVE VATS [1]

MIR S. MULLA [2]

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During the 1960 season a "citizens' committee" to survey the evergrowing problem of *Hippelates* eye gnats and mosquitoes in the Hemet—San Jacinto Valley of Southern California was established. Funds for the survey came from the Board of Supervisors of Riverside County and voluntary contributions by the citizens and organizations of the Hemet—San Jacinto Valley.

The committee requested the State Department of Public Health and the Department of Entomology, University of California at Riverside, to supervise a short-term study to determine the nature and scope of the eye gnat and the mosquito problem in that valley.

During the course of this survey a variety of niches and sources that supported mosquito larval populations were detected. Among them, uncovered olive vats operated by a local packing firm were found to breed large numbers of *Culex p. quinquefasciatus* and, to a lesser degree, *C. peus*. The vats were anywhere from 3 to 8 feet deep and 7 to 15 feet in diameter. There are about 200 vats in this one packing installation and all of them (except those emptied for repair) are kept filled with water from May to October, a period during which they are not used for processing and packing the olives. Since the vats are located in the center of the city of Hemet, and support a fair population of mosquito larvae, they are a constant source of mosquito annoyance.

The olive vats provided an ideal semi-field condition where the effectiveness of granular insecticides in deep bodies of water could be studied. Emulsifiable concentrate formulations were also studied and some were found to be effective at lower concentrations than are necessary to kill susceptible larvae of *C. p. quinquefasciatus* in the laboratory. A plausible explanation for this phenomenon is offered.

Methods and Materials

Vats 42 inches deep and 92 inches across were the only ones (Fig. 1) used in these experiments. The pH of the water in the vats was 6; the temperature of the water ranged from 68° to 78° F. during the day

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[2] The able assistance of Harold Axelrod and Ken Calhoun of the University of California at Riverside is duly acknowledged. Mr. Harvey I. Magy of the State Department of Public Health, Los Angeles, also cooperated in this study.

FIG. 1.—Olive vats located within the city limits of Hemet breed *Culex* mosquitoes.

in September when most of the tests were conducted. The emulsifiable concentrate formulations were applied directly to the water in naturally infested vats by pipetting the required amount of the concentrate and pouring it on the surface. No attempt was made to stir or mix the concentrate into the water.

Larval count by dippings was not satisfactory, but the water was clear and most of the larvae could be easily counted. Three to five 30-second counts were taken before and 24 hours after treatment with the liquid toxicant formulations. Only fourth instar larvae were counted.

In order to study the effectiveness of granular insecticides, larvae of *Culex pipiens quinquefasciatus* from a susceptible laboratory colony were caged in the vats shown in Figure 1. The cages were made from 40-mesh plastic screen and two cages containing 25 fourth instar larvae each were placed in each treated vat. Larval mortality was read after 24 hours of exposure. Both laboratory-prepared and commercially available materials were evaluated.

RESULTS AND DISCUSSION

The use of organochlorine insecticides was precluded due to the possibility that they might leave residues in the grain of the wood of the vats. Therefore, less stable materials such as organophosphorus and carbamate insecticides were evaluated. The effectiveness of the toxicants used in the vats was also determined in the laboratory against a susceptible strain of *C. p. quinquefasciatus* (Table 1) (Mulla *et al.*, 1960).

EMULSIFIABLE CONCENTRATES. Emulsifiable concentrate formulations of malathion, parathion, and five experimental insecti-

TABLE 1.—Effectiveness of various insecticides against fourth instar larvae of *Culex p. quinquefasciatus* in the laboratory

Material	LC_{50} (P.P.M.)	LC_{90} (P.P.M.)
Parathion	0.0045	0.0082
Bayer 29493 (Baytex)	0.011	0.014
Bayer 25198	0.016	0.022
E.N. 18133	0.023	0.031
Bayer 38156	0.027	0.042
Dow K-6882	0.038	0.052
Malathion	0.068	0.120
VC-13	0.150	0.310
Dowco 139	0.580	1.20

cides were evaluated in the olive vats. Parathion was the most effective material of all, followed by Bayer 25198 [*O,O*-dimethyl *O-p*-(methyl sulfinylphenyl) phosphorothioate], Dow K-6882 [*O*-ethyl *O*-(2,4,5-trichlorophenyl) methyl phosphoroamidothioate], and malathion (Table 2). Dowco 139 (4-dimethylamino-3,5-xylol-N-methylcarbamate) was slightly less effective than malathion, but for all practical purposes, the activity of these two materials under the testing conditions is assumed to be essentially the same. In laboratory studies against susceptible fourth instar larvae of *C. p. quinquefasciatus*, however, malathion proved to be approximately 10 times as effective as Dowco 139 (see Table 1).

Compound VC-13 (*O*-2,4-dichlorophenyl *O,O*-diethylphosphorothioate) did not prove too promising; very high rates (over 0.6 p.p.m. or 5 lbs. per acre) were required to obtain good kill of the larvae. This compound, although more effective than Dowco 139 in the laboratory (see Table 1), proved less effective under the testing conditions in the olive vats.

Bayer 38156 was ineffective at the rates applied here to the vats. Under some field-testing conditions this material proved highly effective against fourth instar larvae of *Culex tarsalis* (Mulla *et al.* 1961).

TABLE 2.—Evaluation of larvicides against *Culex pipiens quinquefasciatus* and *C. peus* breeding in olive vats

Insecticide and formulation	Dosage		Avg. No. larvae/count [1]		Percent control
	P.P.M.	Lbs./A	Pretreatment	Posttreatment	
Malathion 80% EC	0.05	0.43	10.3	3.3	67
	0.08	0.69	20.0	0.0	100
	0.10	0.90	6.2	0.3	95
	0.15	1.30	12.0	0.0	100
Parathion 50% EC	0.001	0.009	50.0	38.0	24
	0.002	0.017	45.0	0.0	100
Dowco 139 25% EC	0.04	0.32	19.0	14.0	26
	0.08	0.64	11.0	3.0	73
	0.10	0.77	3.0	0.0	100
Bayer 25198 50% EC	0.002	0.017	48.0	30.0	38
	0.005	0.043	10.3	6.3	39
	0.0075	0.065	10.0	0.0	100
Bayer 38156 50% EC	0.05	0.40	67.0	64.0	5
	0.10	0.80	37.0	30.0	19
VC-13 75% EC	0.2	1.7	5.3	2.8	47
	0.4	3.4	5.1	1.7	66
	0.6	5.1	1.9	0.2	89
Dow K-6882 25% EC	0.005	0.043	63.0	57.0	10
	0.010	0.08	25.0	14.0	43
	0.040	0.24	33.0	2.0	94

[1] Three to five 30-second counts of mosquito larvae were taken per vat. Counts were taken 24 hours after treatment and only fourth instar larvae were counted.

Aside from differences attributable to the occurrence of resistance in the various populations and the nature of the various breeding grounds, no great variations are to be expected in the susceptibility of *Culex p. quinquefasciatus* and *C. tarsalis*. Possibly the emulsifiable concentrate formulation of this material did not emulsify readily in the vats. It is obvious that the concentrations of parathion, Bayer 25198, and Dowco 139 (in parts per million) needed to kill all the larvae in the vats are lower than those required for similar kill in the laboratory (see Table 1). This difference is probably due to the high initial concentration of these insecticides in the upper part of the water where the larvae stay.

Malathion and Dow K-6882 were required at approximately the same concentrations in the vats as those in the laboratory to kill 95 to 100 percent of the larvae. Greater concentrations of VC-13 were required for a given kill in the vats than those required in the laboratory. This suggests that various toxicants follow different courses of distribution in deep bodies of water.

Homogeneous distribution of parathion and malathion took place in glass jars containing water with depths of 2.5 to 15.0 cm. (Rai and Lewallen 1960). In view of the small amount and small depth of water used, even distribution of the toxicants in the absence of any stratification seems plausible. However, these results can not be extended to deeper bodies of water in the field. Many factors such as toxicant solubility in water temperature of the treated water, speed of kill of the toxicant, water movement, larval activity and behavior, and above all, the stability of the toxicant, undoubtedly would influence the effectiveness of a larvicide in deep bodies of water.

It is premature to assume that all toxicants would distribute evenly in deep or shallow bodies of water at the same rate. Bowman *et al.* (1959) showed unequal distribution of DDT in water in test jars and indicated appreciable loss of DDT due to codistillation with water. It is therefore possible that different gradients of concentrations will be maintained by the application of the several toxicants for various periods. Concentration gradients in deep water will be from top to bottom for liquid formulations, and from bottom to top for granular formulations.

It is interesting to note that the dosages administered on the basis of surface area of the water for some of the materials are relatively high and cost-wise prohibitive. This is, of course, due to the greater depth of the water. To maintain effective toxicant concentration, high rates per acre for these materials have to be employed. For maintaining the same toxicant concentration in shallow bodies of water, lower rates per surface area would be needed to result in good kill of the larvae.

Although emulsifiable concentrate formulations of several materials were found to be highly effective, the use of such formulations for the routine control of mosquitoes in the vats was not desirable. Hazard of handling liquid formulations, acquisition of spraying equipment, and the time involved in the spray operation prompted a test of the effectiveness of granular formulations of several insecticides.

GRANULAR FORMULATIONS. Granular formulations of parathion, American Cyanamid E.N. 18133 (*O,O*-diethyl *O*-2-pyrazinyl phosphorothioate), and Bayer 29493 [*O,O*-dimethyl *O*(4-[methylthio]-*m*-tolyl) phosphorothioate] were evaluated at fairly high concentrations. These three toxicants were found to be highly effective against mosquito larvae in the San Joaquin Valley (Mulla *et al.* 1960). Two of the parathion formulations were prepared in the laboratory and the remaining formulations were obtained from commercial sources. The objective of this test was to determine the residual activity of the formulations in the vats, but the vats were drained 7 days after treatment. No data, therefore, could be obtained on long-term control of mosquitoes in the vats beyond one week after treatment.

TABLE 3.—Effectiveness of granular insecticides against fourth-instar larvae of *Culex pipiens quinquefasciatus* [1] placed in olive vats

Granular insecticide	Particle size	Dosage (P.P.M.)	Avg. 24-hour percent mortality of mosquito larvae days after treatment		
			2	3	7
2% Parathion [2]	16/30	0.1	96	100	100
2% Parathion [3]	16/30	0.1	100	100	100
2% Parathion-D [4]	18/24	0.1	8	4	98
		0.2	36	4	32
2% Parathion-N [4]	16/22	0.1	2	2	8
		0.2	100	100	100
5% EN 18133 [5]	8/40	0.1	100	100	100
		0.2	100	100	100
5% Bayer 29493 [6]	30/60	0.1	100	100	100
		0.2	100	100	100
Check		—	0	0	0

[1] From a susceptible laboratory colony.
[2] Parathion impregnated on A-LVM attapulgite granules in the laboratory using AR-60 as solvent.
[3] Parathion impregnated on A-LVM attapulgite granules in the laboratory using Chevron Light Solvent as solvent.
[4] Coated-type granules.
[5] Impregnated on Celite granules, solvent not known, American Cyanamid Company.
[6] Chemagro Corporation, coated-type granules.

Parathion granules prepared in the laboratory proved to be effective at 0.1 p.p.m. and one commercial formulation proved to be effective at the 0.2 p.p.m. concentration (Table 3). No difference between the two laboratory formulations prepared with Chevron Light Solvent and AR-60 could be ascertained at such a high toxicant concentration (0.1 p.p.m.). None of the commercial parathion granules proved effective at 0.1 p.p.m. concentration. But granular formulations of E.N. 18133 and Bayer 29493 were highly effective at the concentrations used.

Small quantities of granular insecticides can be easily dropped into the vats and much lower rates of the effective formulations can be used for initial kill of the larvae. With some granular formulations there is the possibility of stratification of the toxicant released into water having great depths. Effective formulations of parathion, Bayer 29493, E.N. 18133, and other larvicides used at 0.1 to 0.2 p.p.m. probably will control mosquitoes in the vats for a period of 2 to 4 weeks. Stable materials such as E.N. 18133 are liable to result in larval kill for longer periods after treatment.

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SOIL, WATER AND CROP FACTORS THAT INDICATE MOSQUITO PRODUCTION

STERLING DAVIS [1]

INTRODUCTION

The reduction of mosquito populations by eliminating breeding sites on irrigated fields becomes more important every day. There are two ways to eliminate mosquito producing waters, (1) drain them off, and (2) apply only the amount of water the soil will take. The best method for crop production is the second, which is probably best also for mosquito reduction, as it fosters better crop production and better management.

This paper describes a method of evaluating the mosquito-producing potential of a field or area. The same system will point to factors leading to mosquito production and examples of changes to be made.

The SOIL FACTORS considered (A) are *slope, permeability* ("intake rate") and *topography*. The WATER FACTORS (B) are *surface water applied, ground water depth* and *irrigation method*. Other items considered are crops grown and the management of these factors.

Slope.—The slope of a field has much to do with the potential mosquito production. Slopes in excess of 0.5 percent (i.e., one-half foot fall in each 100 feet) generally will not be considered as serious mosquito producers. The slope groups are divided into seven units and rated 1 to 7.

Intake Rate.—The way in which the soil takes water is very important in determining the mosquito production potential. Soils that have intake rates of near 0.1 inch per hour and less can be problem soils. The intake rates are also rated 1 to 7.

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A. SOIL FACTORS (Table 1)

TABLE 1.—Rating and description of factors involved in mosquito production potential

A. SOIL FACTORS

Slope

Rating	Description	Ft./100
1	Very flat	0 –0.1
2	Flat	0.1 –0.25
3	Moderately flat	0.25–0.75
4	Moderate	0.75–1.50
5	Moderately steep	1.50–2.50
6	Steep	2.50–5.00
7	Very steep	Above 5.00

Intake rate

Rating	Description	In/hr.
1	Very slow	0.0 –0.05
2	Slow	0.05–0.1
3	Moderately slow	0.1 –0.25
4	Moderate	0.25–0.50
5	Good	0.5 –1.0
6	Fast	1.0 –2.0
7	Very fast	Above 2.0

Topography

Rating	Description
1	Deep, numerous undulations
2	Moderate, numerous undulations
3	Deep, few undulations
4	Moderate, few undulations
5	Slight, numerous undulations
6	Slight, few undulations
7	No undulations, well prepared for irrigation

Topography.—This factor is the smoothness or unevenness of the field. The rating is from 1 to 7 depending on the depth and number of undulations. As these undulations get deeper and more numerous the mosquito potential is greater.

Surface Water Used.—When the water right or available water for use is high, then more water is used. When the consumptive use of the plant is exceeded the

B. Water Factors (Table 2)

TABLE 2.—Rating and description of factors involved in mosquito production potential

B. Water Factors

Surface water used

Rating	Description
1	Abundant—More than 10 ac. ft./ac./year
2	Excess—5 to 10 ac. ft./ac./year
4	Consumptive Use (plus) 2.5 to 5 ac. ft./ac./year
7	Consumptive Use (minus) 2.5 ac. ft./acre/year or less

Ground water

Rating	Description
1	Shallow—Less than 18"
2	Moderate—18 to 30"
3	Good—30 to 60"
4	Excellent—More than 60"

Irrigation method

Rating	
1	Ponding
2	Wild flooding
3	Border ditch
4	Contour ditch
5	Border
6	Furrow
7	Sprinkler

excess water (above plant needs) is left to pond or cause trouble in other ways. The surface water is rated 1, 2, 4 and 7, depending upon the amount available.

Ground Water.—Ground water can cause serious trouble if it is high and does not allow excess water to get away. Ground water is rated 1 through 4, depending on depth to water.

Irrigation Method.—While the operation of a given irrigation method is very important there are certain physical factors in each method that favor mosquito production. The methods are rated 1 to 7.

C. Crop Factors (Table 3)

TABLE 3.—Crop Factors

Rating	
1	Native grass (hay or pasture), water plants
2	Pasture and grasses
5	Alfalfa
6	Small grains
7	Row crops

Crops are rated 1, 2, 5, 6, 7. Some crops will allow standing water while others will not. Crops not listed could be added with crops having the same response to standing water.

D. Management Factors (Table 4)

TABLE 4.—Management Factors

Rating	
1	Very poor
2	Poor
3	Fair
4	Good to fair
5	Good
6	Very good
7	Excellent

This factor is rated 1 to 7. A main concern of this factor will be the care given to irrigation water. The interest and experience of the operator will have to be considered.

TABLE 5.—Mosquito production potential rating table

Soil			Water						
Slope	Intake rate	Topography	Surface used	Ground	Irrigation method	Crop	Management	Ave.	Mosquito Potential
1	1	1	1	1	1	1	1	1.5	Extremely high
2	2	2	2	2	2	2	2	2.0	High
3	3	3	3	3	3	3	3	2.5	Moderate
4	4	4	4	4	4	4	4	3.0	Slight
5	5	5	5	5	5	5	5	3.5	None
6	6	6	6	6	6	6	6		
7	7	7	7	7	7	7	7		

RATING THE MOSQUITO PRODUCTION POTENTIAL

Rating is done conveniently with the aid of a table (Table 5). The purpose of the rating table is two-fold. First, potential mosquito production of an area can be estimated, and second, and more important, the table points to the trouble-causing factors and assists in analysis of each problem. The lower the rating the greater the possibility of mosquito production.

Presented below are some examples of actual fields where mosquito counts have been made and irrigation water measured, pointing out their trouble-causing factors and possible solutions.

EXAMPLE 1.

California pasture field, low intake, flat slope, contour dikes (ponding), much water used and no ground water. The factors would add up like this:

Factor	Rating
Slope	1
Intake rate	2
Topography	2
Water used	1
Ground water	4
Irrigation method	1
Crop	2
Management	2
Total	15
Average	2

Rating—High mosquito production

ANALYSIS: *Slope*—Nothing much can be done; *Intake rate*—No change; *Topography*—Level, change rating from 2 to 6, *Water used*—Consult irrigation guide, change rating from 1 to 4; *Ground water*—Leave the same; *Irrigation method*—Install borders, change rating from 1 to 5; Crop—Leave the same; Management—More care, change rating from 2 to 6. *Now add up:* 1, 2, 6, 4, 4, 5, 2, 6; total, 30. Average, 3 5/8: No mosquitoes.

Changes: Level the land, change irrigation system and amount of water used, and take more care in management. *Result*—No mosquitoes, better production, more valuable land.

EXAMPLE 2.

Bluejoint meadow, Montana, flat, low intake rate, much water.

Factor	Rating
Slope	1
Intake rate	1
Topography	1
Water applied	1
Ground water	2
Irrigation method	1
Crop	1
Management	1
Total	9
Average	1.2 = Extremely high mosquito production

ANALYSIS AND CHANGES. *Slope*—No change; *Intake rate*—No change; *Topography*—Level, change from 1 to 7; *Water applied*—Apply as per guide, change from 1 to 4; *Ground water*—With less water applied this will probably change from 2 to 4; *Irrigation method*—Border, change from 1 to 5; *Crop*—Change to alfalfa, 1 to 5; *Management*—More care, change from 1 to 5; *Now add up:* 1, 1, 7, 4, 4, 5, 5, 5; total, 32. Average, 4: No mosquitoes.

Production change from one-half ton bluejoint hay per acre to 5 tons per acre of alfalfa.

EXAMPLE 3

California cotton field, flat, high intake rate, water pumped, no ground water.

Factor	Rating
Slope	1
Intake rate	5
Topography	6
Water used	4
Ground water	4
Irrigation method	6
Crop	7
Management	5
Total	38
Average	4+ = No mosquitoes

Example 4

Alfalfa field, Montana, borders, flat, no water-table.

Factor	Rating
Slope	1
Intake rate	1
Topography	7
Water used	4
Ground water	4
Irrigation water	5
Crop	5
Mangement	6
Total	33
Average	4+ = No mosquitoes

Summary

A combination of factors is required to produce mosquitoes; the rating table points out the problem factors. Use of information from irrigation guides, land leveling, and attention to all items involved can reduce mosquito-breeding sites.

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UTAH MOSQUITO ABATEMENT ASSOCIATION

Sixty per cent of the people in the state of Utah are now living within the boundaries of organized mosquito abatement districts.

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OBSERVATIONS ON *CULICOIDES OBSOLETUS* (MEIGEN) IN THE LABORATORY (DIPTERA:CERATOPOGONIDAE)[1]

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INTRODUCTION. "The black fly, when preparing to bleed you, can be seen; the mosquito warns you with his music; but punkies can be neither seen or heard, and if they could, what would it avail? You might, could you see them, kill an occasional one, but their funerals are marvelously well attended.

"They breed any time, and are ready for business in fifteen minutes after birth. They can drill a hole in a persons's skin as deep as their own bodies are long in just two-fifths of a second, eat a square meal off his blood and get away in another fifth, digest it and return hungry during the other two."

The foregoing quotation, from a book on the Adirondack Mountains of New York, was written in 1872 by H. Perry Smith and titled, "The Modern Babes in the Wood or Summerings in the Wilderness." It indicates that *Culicoides obsoletus* (Meigen), the punkie, is a serious pest in the Adirondacks and also that there is a considerable fund of "information" on its life history and habits.

A study of *Culicoides,* with particular reference to those attacking man, was undertaken by the New York State Museum and Science Service in 1959 and continued in 1960. The financial assistance of the Adirondack Entomology Research Fund and the field and laboratory assistance of Max McFadden in 1959, Thomas Watthews in early 1960, and Richard Riley in late 1960 in these studies is acknowledged. Collections of several thousand specimens attacking man from many locations in the Adirondacks during these two years were all identified by the author as *C. obsoletus* (Meigen).

[1] Published by permission of the Assistant Commissioner, New York State Museum and Science Service. Journal Series No. 49.

Indentification of representative specimens was confirmed by W. W. Wirth, U. S. National Museum.[2] In addition to *C. obsoletus,* two other species in the *C. obsoletus* group have been collected in the Adirondacks. Of these, *C. chiopterus* (Meigen) is not abundant and does not commonly bite man.[3] The other, an apparently undescribed species, is so uncommon that for purposes of this paper it is disregarded. The identification of species in the *C. obsoletus* group will be considered in a separate paper.

LONGEVITY OF WILD-CAUGHT FEMALES IN CAPTIVITY. It has become increasingly apparent in recent years that females of many species of biting Diptera do not invariably require a blood meal for the production of eggs and that many (if not most) feed on nectar as a source of energy (see review by Downes, 1958a).

One phase of our laboratory experiments with wild-caught *C. obsoletus* females was a study of their longevity, oöcyte development, and oviposition in the laboratory.

Punkies attacking man in search of a blood meal were captured and kept individually in cotton-stoppered four-dram

[2] The statement by Metcalf (1932) that *Culicoides biguttatus* (Coq.) is the important pest species in the Adirondacks was probably based on collections of adults not attacking man or on misidentified specimens. In our study, *C. biguttatus* was present in small numbers in light trap catches but was not collected attacking man.

[3] Only two references that mentioned biting by *C. chiopterus* were noted in the literature. Amosova (1958) cites Remm who recorded it as blood-sucking, particularly in the spring and autumn. Campbell and Pelham-Clinton (1960) state that they have only a few records of this species attacking animals but point out that specimens of *C. chiopterus* may well have been confused with *C. obsoletus* and overlooked.

vials. Some were allowed to engorge while others were collected before they could feed. A piece of moist cotton was placed in the bottom of each vial. The cotton in some vials was dipped in tap water and in others in a solution of refined cane sugar (sucrose). No attempt was made to maintain a standard strength solution because of subsequent changes caused by evaporation and the addition of more water to the cotton as it dried. The vials were kept inside the laboratory where the temperature averaged approximately 70 degrees during the test period.

Under these conditions, wild-caught females survived up to 51 days. Their survival times with or without blood meals and with or without sugar solution are shown in Figure 1. A convenient index to these differences is the time elapsed before 90 percent of the females died. These data are given in Table 1.

It can readily be seen from the figure and the table that a blood meal has little appreciable effect on longevity and that access to sugar solution greatly prolongs life.

TABLE 1.—Number of days from capture to ninety percent mortality of wild-caught *C. obsoletus* females with and without blood and sugar

Number of specimens	Blood meal	Sugar available	Days to 90% mortality
200	+	+	29.6
100	—	+	28.5
100	+	—	4.8
100	—	—	5.7

These data agree well with those of Parker (1950) who found that *C. obsoletus* gp. adults in Scotland survived an average of three weeks in moist environments when given access to nutrients in the form of a raisin or piece of prune. He records a maximum longevity of three and one-half months for a *C. obsoletus* group specimen and also notes that the other species of *Culicoides* tested survived

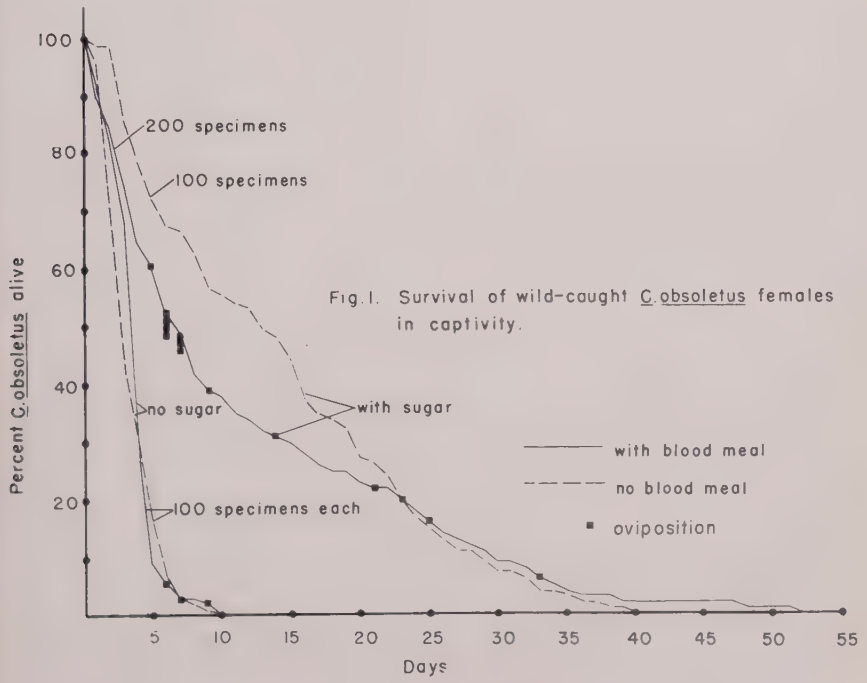

Fig. 1. Survival of wild-caught C. obsoletus females in captivity.

for much shorter periods (nine to 11 days) under the same conditions.

The abdomens of wild-caught specimens attacking man are usually much flattened. When placed on cotton moistened with sugar solution they almost immediately inserted their mouthparts into the cotton to feed. Their abdomens rapidly filled and became swollen with sugar solution. In contrast, specimens placed on cotton moistened only with water did not attempt to feed and when observed thereafter still had flattened abdomens.

DEVELOPMENT OF OÖCYTES IN RELATION TO THE BLOOD MEAL. Although the abdomens of punkies attacking man are usually flattened, when specimens are preserved in 90 percent alcohol they become swollen by osmosis. Since the walls are partially transparant some of the internal structure can be discerned. The mid- and hind-gut are inconspicuously appressed to the inner dorsal wall of the abdomen and the ovaries are small so that the abdomen is almost empty at this time. After a blood meal the abdomen is filled by the blood-distended stomach. Then as the blood is digested and the by-products eliminated the maturing oöcytes tend to keep the abdomen full.

The rate of blood digestion and oöcyte development was investigated by examining females killed at regular intervals after a blood meal. At least five females were killed on each of the 10 days following a blood meal. Others were killed at less regular intervals thereafter. Examination of living and preserved specimens indicated that there was little change in the volume of the blood meal during the first two days although it solidified and became opaque. By the third day small black-pigmented granules and rods (digested blood by-products, see Megahed, 1956) could be seen in the stomach along with apparently undigested blood. By the fourth day the blood was completely digested and the by-products largely or entirely eliminated. Megahed (1956) reported a similar pattern of digestion for *C. nubeculosus* Meigen except that digestion began within 24 hours and was completed within 72 hours.

The ovarian follicles of specimens attacking man were small, the largest measuring about 32 x 34 microns. After a blood meal the ovaries are pressed against the dorsolateral wall of the abdomen and are difficult to locate. In one such specimen the largest follicles measured about 42 x 32 microns the day after a blood meal. After three days the oöcytes nearly fill the follicles which have increased in size so that they can readily be seen in dissections and often through the wall of the abdomen. By the third day the largest oöcytes average about 112 x 46 microns. By the fourth or fifth day they reach approximately their pre-oviposition length of 262 to 340 microns and width of 46 microns and have assumed their characteristic cigar-like shape.

DEVELOPMENT OF OÖCYTES WITHOUT A BLOOD MEAL. When reared, unfertilized females that had not been given a blood meal were dissected it was surprising to find that the ovarian follicles were larger than those of wild-caught females. The largest follicles measured about 50 x 34 microns compared to 32 x 34 microns for those of wild-caught females. The enlarged follicles and the considerable amount of stored food material present in the abdomen of newly-emerged females suggested that the first ovarian cycle might be autogenous. Five reared unmated females that were given sugar solution survived for 6, 8, 17, 21 and 37 days respectively. The specimens that died on the eighth and twenty-first days after emergence contained large, apparently mature oöcytes measuring about 285 microns for the former and about 340 microns for the latter. The oöcytes of the other three specimens had not increased in size. These observations show that *C. obsoletus* females do not require blood for development of the first batch of eggs. Although it is highly probable that the first ovarian cycle is autogenous this cannot be assumed until it can be demonstrated that these oöcytes develop into viable eggs. Downes

(1958b) notes that the first ovarian cycle of *Culicoides gigas* Root and Hoffman is autogenous and suggests that, since it bites man, the second ovarian cycle requires a blood meal. Amosova (1958) notes that *C. dendrophilus* Amosova follows a similar pattern and cites records of autogeny for *C. circumscriptus* Kieffer and *C. riethi* Kieffer.

Oviposition in Captivity. When annoying wild-caught *C. obsoletus* females were allowed to take a blood meal and then held in captivity their oöcytes almost always developed to pre-oviposition size if the females survived for five or six days. However, most of the females died without laying eggs. Viable eggs were laid by seven percent of 200 wild-caught females that were given a blood meal and had access to sugar solution and by three percent of 100 similar females that had a blood meal but no sugar solution.

In contrast, no eggs were laid by 200 wild-caught females that were not given a blood meal. Of these, one half had access to sugar solution and the other half did not. Unlike those of the blood-fed females, the oöcytes of these females did not increase in size when held in captivity.

Eggs were laid between the fifth and thirty-third day following a blood meal. Nine of the 17 ovipositions occurred on the sixth or seventh day (Figure 1). These observations agree with those of Parker (1950), who noted that *C. obsoletus* group females generally laid eggs one to two weeks after a blood meal. Hill (1947) states that females lay eggs about two and one-half weeks after a blood meal.

The 17 females mentioned above laid an average of only 14.7 eggs (range 2–42) while 10 wild-caught gravid females captured in light traps contained an average of 36.1 oöcytes (range 18–58). In examining gravid females it was interesting to note that while both ovaries usually were filled with large oöcytes, sometimes one ovary had large oöcytes and the other undeveloped ones.

Hill (1947) states that *C. obsoletus* lays about 75 eggs (range 35–120) while Parker (1950) records 30–55 eggs per batch for *C. obsoletus* group specimens.

The reluctance of the females to lay eggs in captivity in our studies suggests that some modification of the conditions in the vials is desirable. Moist filter paper was used as a substrate in holding chambers by Hill (1947) and Parker (1950), apparently with considerable success in obtaining oviposition from *Culicoides* females including *C. obsoletus* gp. species.

In our studies the eggs were laid singly on moist cotton, usually all within a 24-hour period. The females usually became entangled in the cotton and died within 24 hours of oviposition, and in some cases before laying their full complement of eggs. The longest that a female survived after oviposition in our studies was six days. In contrast Parker (1950), using a moist filter paper substrate, was able to keep *C. obsoletus* group females (but not other *Culicoides*) alive for a reported average of 5.5 weeks following oviposition. This statement by Parker may be incorrect since he states in the same paragraph that *C. obsoletus* group females live an average of three weeks in captivity.

The presence of relict eggs, indicating a prior ovarian cycle was observed in three specimens out of several hundred dissected for various purposes. Parker (1950) reported that two *C. obsoletus* group females took a second blood meal in captivity following oviposition and laid eggs a second time. It seems likely that *C. obsoletus* has more than two ovarian cycles but this has not been demonstrated to date.

Eggs and Newly Hatched Larvae. The hatching time for 20 eggs laid by *C. obsoletus* females in captivity ranged from four to seven days at room temperatures averaging about 70° F. Hill (1947) reported a range of 30 hours to 11 days for hatching; and Parker (1950), two to three days at temperatures averaging about 63° F. In our studies ten of the twenty eggs observed individually hatched on the fifth day. They hatched equally well under water or on moist cotton exposed to the air. Three of the eggs were placed on

damp cotton which was allowed to dry out. The cotton and eggs were apparently dry after 24 hours. One of the eggs placed in water at this time hatched in a total of five days. The other two were allowed to dry for two more days. At this time the eggs had started to collapse inwardly because of the drying. The eggs were immersed in water and two apparently normal larvae emerged, one six days after oviposition and the other a day later. These observations tend to support the more detailed studies of Parker (1950) with *C. pulicaris* group eggs. He found that the eggs may survive considerable desiccation and that drying prolongs the egg stage.

The individual eggs are medium brown in color and cigar-like in shape. Egg shells measured after larval emergence averaged 366 microns in length and 49 microns in maximum width (range in length 330–390 microns). Hill (1947) records a length of 380 microns (range 310–410 microns) and width of 76 microns for *C. obsoletus* eggs. The apparent difference in egg width between Hill's measurements and ours may be due to an increase in width due to flattening by the pressure of a cover slip in the case of Hill's measurements. When eggs of Adirondack specimens were slightly flattened by the pressure of a cover slip on a slide they measured 75 microns in width instead of the unflattened 49 microns.

Under high magnification about 10 longitudinal irregular rows of short thick stalks can be seen on the surface of the egg shell. These are enlarged apically and look like small mushrooms when examined under the microscope at about 970 X. These stalks are somewhat longer toward the anterior and posterior ends of the egg and range from less than one to about three microns in length. They are not so long as those illustrated and described by Hill (1947). In this connection Parker (1950) noted that the "suckerlike" structures on *C. obsoletus* gp. egg shells were not so long as indicated by Hill (1947) and suggests that this may be due to species differences within the *C. obsoletus* group.

The recently hatched larvae are pale white. The head capsule is barely distinguishable from the rest of the body under low magnification. Only the eye spots are dark and distinct. Ten of these larvae averaged 546 microns in length. The head capsules averaged 73 microns in length and 51 microns in width. Hill (1947) states that the larval head length of British specimens is about 0.5 mm and the head 77 microns long and 70 microns wide. This difference in width between Hill's measurements and ours may again be due to flattening by the cover slip. The larvae have a prothoracic proleg the details of which are difficult to make out. It has 2 or 3 pairs of long slender spines (about 9 microns) and about five transverse rows of fine combs. The presence of a proleg in first instar larvae of *C. obsoletus* was first reported by Kettle and Lawson (1952) who cite an unpublished communication from Parker.

SUMMARY. Wild-caught *C. obsoletus* females survived up to 51 days in captivity. Those that did not have a blood meal survived about as long as those that did. Those that were given sugar solution lived about five times longer than those that were not. Specimens attacking man usually have small oöcytes. After a blood meal the oöcytes grow rapidly so that in four to five days they fill the abdomen. The oöcytes of newly-emerged, reared, unmated females were larger than those of wild-caught females collected attacking man. In two instances they grew to preoviposition size when the females were kept alive and given sugar solution but not a blood meal. It seems probable that the first ovarian cycle of *C. obsoletus* is not dependent on a blood meal.

Among the wild-caught females captured while attacking man and kept in captivity, seven percent given blood meal and sugar solution laid eggs and three percent given a blood meal but no sugar solution laid eggs. None of those that were not given a blood meal laid eggs.

C. obsoletus females laid eggs between five and 33 days after a blood meal. The eggs hatched in four to seven days. The newly hatched larvae have a distinct proleg equipped with spines.

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California Mosquito Control Association, Inc.

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OPERATIONAL AND SCIENTIFIC NOTES

NEW, IMPROVED ONE-MAN OPERATED JEEP MIST BLOWER

G. PAUL JONES
Manager, Marin County Mosquito
Abatement District

In 1955 the Marin County Mosquito Abatement District constructed a one-man operated mist blower and the construction details were reported in *Mosquito News* for June 1955. Compared to the present model that mist blower was very crude.

The newly designed mist blower (Fig. 1), which was constructed at the District shop, is mounted on a seventy-five (75) gallon tank which has a 6″ x 6″ circular sump built in. A hole was cut in the floor of the jeep pick-up body so that the sump rests below the floor. With the sump it is possible to pump the tank completely dry. This prevents rusting of the tank and makes for longer life.

The dimensions of the seventy-five (75) gallon tank are 36″ x 31″ x 16″, the blower is mounted on a double "U" metal strap frame with proper bracing. The blower, the gasoline engine and the insecticide pump are mounted on top of the tank. The blower is at the right, the gasoline engine is in the center and the insecticide pump is on the left. The tank is mounted on the jeep so that the blower discharges to the right. The front side of the blower housing has a babbitted flange type bearing attached to it by bolts. A piece of tubing is welded to a metal plate which in turn is welded to the front "U" bracket. This tubing supports the blower housing by supporting the flange type bearing. The end of the tubing is locked just inside the blower housing so that the blower housing cannot move sideways. A 1-3/16″ shaft runs through the inside of the tubing which supports the blower housing through the flange bearing. Pillow block bearings mounted on the top of the strap frames support the drive shaft. The Westinghouse wheel is secured to the shafting inside the blower by key and lock screw.

The blower uses a size 507 standard side plate Westinghouse wheel which turns at 3800 RPM; the blower housing is 6″ wide, 21″ in diameter and has a 7″ diameter discharge pipe surrounded

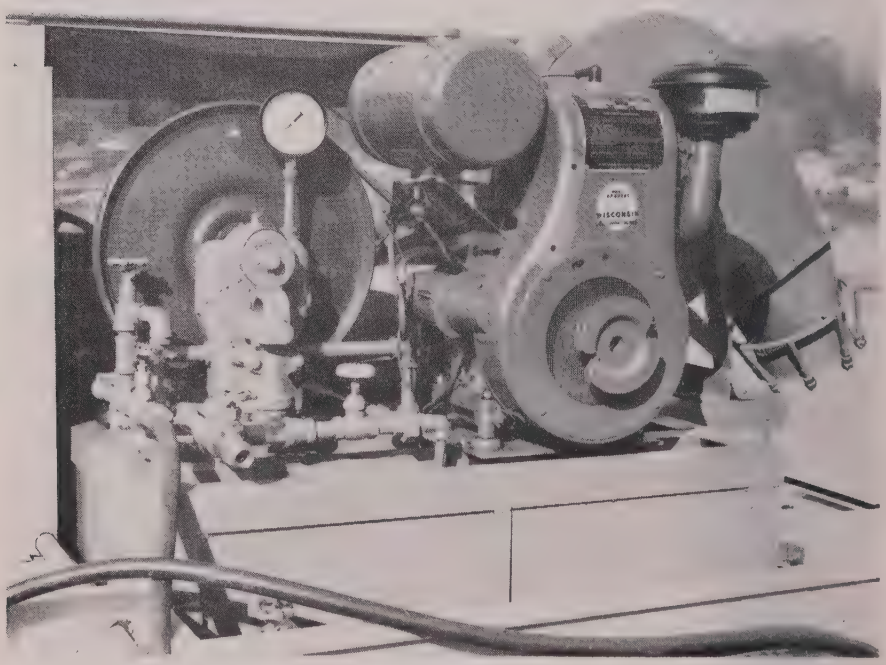

FIG. 1.—New improved one-man operated Jeep mist blower.

by eight Spraying Systems Company nozzles, using flat atomizing 15°, #150067 tips.

The nozzles are supplied with insecticide spray by a Meyers Model 5302 high pressure pump which operates at pressures between 150 to 200 pounds. Approximately two (2) gallons of spray material are discharged into the air stream per minute.

The blower housing is moved by a 6-volt 1954 Pontiac electric window motor, fastened to the bottom bracing of the blower mounting frame. A 2-inch sprocket on the electric window motor is connected by #40 chain to a 10-inch sprocket mounted on the side of the blower housing. Two push button switches located inside the jeep on the dashboard move the blower up and down. Credit is given to the Sonoma County Mosquito Abatement District for the idea of using a car window motor for changing blower directions.

Flow of insecticide to the blower nozzles is controlled from inside the cab of the jeep by attaching a small cable to a Food Machinery Corporation 3/4" ratchet valve #118–2527. One pull of the cable turns the valve on and the following pull shuts it off. The blower and the insecticide pump are driven by a Model AENL 9.2 HP Wisconsin air-cooled motor. A 2-inch pulley on the engine driveshaft drives a 16-inch pulley on the insecticide pump shaft. An 8.2-inch pulley on the engine drives a 6.2-inch pulley on the blower shaft. Type "B" belts are used. The engine is started and stopped from inside the cab by push button switches. Choking of the engine and regulation of the engine speed is done from within the cab of the jeep. Once the operator fills his spray tank he need not leave the jeep cab until it is empty. A 15-gallon insecticide concentrate tank, with visible gauge, is mounted above the left fender of the jeep. Turning a valve lets the desired amount of insecticide concentrate flow into the spray tank where it is mixed with water. Valves, hose and pipe arrangements permit filling the spray tank with water from field sources.

For larviciding purposes 4 nozzles may be capped off and larger tips used in the remaining nozzles. Valves and piping make it possible to use a hand spray gun instead of the mist blower when desired. By removing a few bolts the blower and tank can be removed from the jeep as a unit. Agitation is supplied on one model by use of a six (6) volt electric window motor attached to a vertical drive shaft, which turns a propeller inside the insecticide tank. The motor does not have sufficient power for constant use; however, our stable solutions need little agitation.

There is practically no spray drop-out near the jeep because of the high pump pressure and high velocity of the airstream. Spray particle sizes are very small. This makes the blower a good adulticiding tool for *Aedes sierrensis*, which is our big problem.

The Occurrence of *Orthopodomyia alba* Baker in Oklahoma (Diptera: Culicidae) *

W. E. Johnson, Jr.
Department of Zoological Sciences, University of Oklahoma **

According to Jenkins and Carpenter (1946) *Orthopodomyia alba* Baker is considered to be a rare, restricted, local tree hole mosquito which has aroused interest each time that it has been collected. *O. alba* is considered to be closely related to *Orthopodomyia signifera* which selects the same larval habitat. The adults of the two species are difficult to distinguish.

Larval collections of *O. alba* have previously been reported from the states of Alabama (Shields and Miles, 1937); Kentucky (Kitzmiller, 1945); Louisiana (Harden, 1945); Mississippi (Middlekauff and Carpenter, 1944); Missouri (Gurney, 1943); New Jersey (Lake, 1953); New York (Baker, 1936); North Carolina (Schoof and Ashton, 1944); Texas (Breland, 1947) and Virginia (Dorsey, 1944). Jenkins and Carpenter (1946) cite an unpublished report of the occurrence of *O. alba* in Illinois by Ross.

Seventy-nine third instar larvae and sixty-two fourth instar larvae of *O. alba* were collected from a tree hole in an American Elm tree *(Ulmus americana)*, in association with twenty, fourth instar larvae of *O. signifera*. This single collection was made in the Mount Scott Camp-

* This study was aided by a Fellowship from the National Medical Fellowships, Inc., through funds appropriated by the National Foundation.

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ground of the Wichita Mountains Wildlife Refuge (Comanche County, Oklahoma) on February 26, 1960. The water temperature, at the time of the collection was 34° F. The tree hole contained turbid, dark brown water. In the laboratory the larvae were reared to adults, at a temperature of 12° C., in isolation vials containing tree hole water from which the larvae had been collected. Larval and pupal exuviae were collected and preserved in 80 percent alcohol in small vials.

The author's identification of the species was verified by Dr. Cluff E. Hopla of the Department of Zoological Sciences of the University of Oklahoma, to whom I am deeply grateful.

Relatively few references have been presented in the literature pertaining to Oklahoma mosquitoes. The most complete study of the mosquitoes of Oklahoma was made by Rozeboom (1942) who recorded forty species of mosquitoes in the State. Roth (1945) reported the occurrence of *Psorophora longipalpis* in Oklahoma. Griffith (1952) recorded eleven additional species, bringing the total known species for the State to fifty-two. The collection of *O. alba* in Oklahoma brings the total known species of mosquitoes for the State to fifty-three.

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OCCURRENCE OF *Orthopodomyia californica* IN ARIZONA

PAUL T. RIGBY [1] AND HARVEY AYERS [2]

Mosquito larvae were collected from tree holes in Garden Canyon near Fort Huachuca, Arizona on 1 September 1960 and 21 October 1960 by the junior author. The specimens were examine by the senior author and determined to b *Orthopodomyia californica.* It is believed tha this species has not been previously reported fro Arizona, and therefore it becomes a new stat record. It has been known only in California according to Stanley J. Carpenter.

[1] Sixth U. S. Army Medical Laboratory, Fort Baker, California.

[2] Preventive Medical Technician (MSG), Office of the Post Surgeon, Fort Huachuca, Arizona.

EDITORIAL

Wm. E. Bickley

Many important items of business were acted upon by the AMCA Board of Directors and or members assembled at the Anaheim meeting. The report of the Recording Secretary will be published in a subsequent number of *Mosquito News*. It is a policy of the Board to keep all members fully informed about Association affairs. It is the hope of your President that a greater proportion of members will participate in Association work, and he is trying to stimulate interest in every possible way.

One significant transaction at our last annual meeting was an amendment to the bylaws providing for election of certain officers by mail ballot. This necessitates a report of the Nominating Committee "four months prior to the next annual meeting" so that the executive secretary can prepare ballots and mail them three months prior to the annual meeting. All members should feel free to make suggestions to the Nominating Committee. The members of the Nominating Committee are as follows:

D. M. Jobbins, Chairman, New Jersey Agricultural Experiment Station, Rutgers University, New Brunswick, New Jersey

Marshall Laird (Canada), Institute of Parasitology, Box 102, Macdonald College, P. O., Quebec, Canada

Richard O. Hayes (North Atlantic), 15 N. Walker Street, Taunton, Massachusetts

J. Melton Williams (South Atlantic), Dir. Mosq. Cont., Court House Building, Sarasota, Florida

Franklin Wray (Northeast Central), Desplaines Valley MAD, 8130 Ogden Avenue, Lyons, Illinois

Joseph E. Webb (Southeast Central), Prev. Med. Div., Office of Surgeon General, Department of Army, Washington 25, D. C.

Glen C. Collett (Northwest Central), Salt Lake City MAD, 401 City and County Building, Salt Lake City, Utah

Richard Eads (Southwest Central), Quarantine Station, USPHS, Brownsville, Texas

Gaines W. Eddy (North Pacific), P. O. Box 332, Corvallis, Oregon

Austin W. Morrill, Jr. (South Pacific), DD-111, Dist. Pub. Wks. Office, Hq. 12th Naval District, San Bruno, California

Pedro Galindo (Mexico, Central and South America), Gorgas Memorial Lab., Apartado 1252, Panama, R. P.

ASSOCIATION NEWS

ABSTRACTS OF SUBMITTED PAPERS, JOINT MEETING OF AMCA AND CMCA, ANAHEIM, CALIF., JAN. 31–FEB. 3, 1961

NOTE: Most of the papers presented at the Joint Annual Meeting will be printed in the *Proceedings and Papers of the California Mosquito Control Association,* which will be published by the California Association in the fall of the present year. A copy of these *Proceedings* will be sent free of charge to each AMCA member and subscriber to *Mosquito News,* and reprints may be ordered by authors as with *Mosquito News.*

However, where clearance of a paper was obtained specifically for publication in *Mosquito News,* or where for some other accepted reason (e.g., where a paper is one of a series or group) the paper is considered for publication in *Mosquito News* in the usual way, with an abstract in the California proceedings. These are the same procedures that were followed when the AMCA met with the California Association in 1949 and 1955.

Abstracts of the papers which were submitted with the titles, are given below. Abstracts of papers which appear in this issue of *Mosquito News* or are expected to appear in the next issue, are not included, nor are abstracts which do not add to the information already supplied by the title.

Aedes schizopinax DYAR IN THE WESTERN UNITED STATES. Lewis T. Nielsen, Department of Zoology and Entomology, University of Utah. *Aedes schizopinax* Dyar is one of the rarest mosquitoes in the Western United States, but is now known to occur in the states of California, Colorado, Idaho, Montana, Nevada, Utah, and Wyoming.

Taxonomically on the basis of the male genitalia the species appears to be allied to the *Aedes punctor* complex; it is very distinctive, being readily recognizable in the adult male and female and larval stages. Some of the most distinctive features are discussed in this paper.

Little is yet known on the biology of this species.

CHROMOSOME STUDIES WITH FIRST INSTAR MOSQUITO LARVAE. James D. Long, Biology Department, Sam Houston State Teachers College, Huntsville, Texas. An abbreviated technique has been developed for the preparation of nuclear materials used in mosquito chromosome studies. The procedure involves the utilization of first instar larvae as a source of tissues to be studied. The head capsule of the larva is removed and squashed in a standard chromosome stain. Chromatin material stained in this fashion can be readily identified and is apparently adequately stained for detailed study of chromosomes.

CURRENT STATUS OF TROPICAL MOSQUITOES IN THE LOWER RIO GRANDE VALLEY OF TEXAS. Richard B. Eads, Senior Scientist (R) U. S. Public Health Service, U. S. Quarantine Station, Brownsville, Texas. The several species of tropical mosquitoes reported in the United States only from the Lower Rio Grande Valley are discussed. Included are comments on the apparent disappearance of *Anopheles albimanus* and observations on *Haemagogus equinus.*

FINDINGS ON THE SOIL HABITAT, BIOLOGY AND CONTROL OF *Leptoconops torrens* TOWNSEND. R. H. Whitsel, T. H. Lauret, C. A. Vickery, Jr., and H. E. Munsterman, San Mateo County Mosquito Abatement District, Burlingame, California. Recent studies of the biting black gnat *(L. torrens)* within San Mateo, Santa Clara, and Solano Counties, California, indicate that specific locations within soil series may account for a large proportion of the observed adult population. Since actual control work necessarily requires de-

limiting positive source areas within the many thousands of acres of cracked clay soils, one of the main objectives has been to describe the general soil characteristics on actual positive black gnat sites.

Studies of adult emergence on specific soils, emergence correlated with cracking potential, and soil moistures and temperature data relating to various pertinent clay soils are forthcoming. Susceptibility of the black gnat to insecticides and further results on insecticidal testing on positive gnat producing soil in Menlo Park and U. S. Naval Radio Station near Dixon, California, are to be presented. Observations on the biology of *L. torrens* are to be included.

Improved Techniques for the Laboratory Rearing of *Aedes aegypti*. John E. Porter and George Kozuchi, U. S. Quarantine Station, U. S. Public Health Service, Miami Beach, Florida. Three techniques are described which have proved useful in rearing *Aedes aegypti* at the Miami Beach, Florida Quarantine Station. These are: (1) Preparation of an adult feeding solution consisting of 1 part of a 2 percent propyl & methyl paraben to 3 parts of a honey-water solution to prevent fermentation and molding and a preliminary report on the effects of paraben solutions for mold prevention on egg deposition paper; (2) a honey-water solution feeder which is impervious to egg deposition and rapid evaporation; and (3) an easily constructed and inexpensive sleeve-type cage for establishing colonies of mosquitoes from small larval collections.

Mosquito Larvae Recovered from Cemetery Urns and Cisterns in Various Seaport Cities in Louisiana, Mississippi, and Alabama. Burton R. Evans and Edward J. Fink, U.S.P.H.S., U. S. Quarantine Station, New Orleans, La. A summary of the mosquito larvae recovered from cemetery urns and cisterns from January thru September, from 1959–60. A total of eight species were recovered from the cemetery urns, and three from the cisterns.

Fluctuations in Abundance of Common Species of Mosquitoes in Salt Lake County, Utah. Jay S. Graham, South Salt Lake County Mosquito Abatement District, Midvale, Utah and Don M. Rees, University of Utah, Salt Lake City, Utah. Careful observations for the past 5 years of the numbers of the common species of mosquitoes in Salt Lake County, Utah, have shown that the abundance of some species has fluctuated considerably in different years. *Culex tarsalis* greatly increased in numbers in 1958 but returned to a more normal level in 1959 and 1960. *Culiseta inornata* has shown successive increases in number in 1958, 1959, and 1960. *Culex pipiens* also increased in numbers in 1959 and 1960. Populations of *Aedes dorsalis* have remained relatively constant during this same interval. The factors responsible for these population changes are not fully understood but patterns of precipitation and temperature interacting with irrigation practices are partially responsible.

Natural History of WEE and SLE Viruses at Different Elevations. John S. Blackmore, Louis C. LaMotte, and A. D. Hess, Encephalitis Section, Public Health Service, Greeley, Colorado. Observations were made in a canyon extending from 5600 to 8580 feet above sea level near Boulder, Colorado, to determine if *Culex tarsalis* mosquitoes move up a canyon free of indigenous *C. tarsalis* to higher elevations during the summer and fall and if WEE or SLE virus is introduced into the fauna of the higher elevations. *C. tarsalis* appeared at higher elevations in small numbers only in the fall. Female mosquitoes which moved up the canyon were non-feeding, nulliparous specimens. However, WEE transmission rates, even at the highest study site, were comparable with rates at the mouth of the canyon. SLE transmission occurred only in the lower study areas. The evidence suggests: (1) that there is a fall dispersal of nulliparous *C. tarsalis* to higher elevations; and (2) that there may be another vectoring

mechanism for WEE virus at upper elevations.

Techniques Used to Determine the Physiological Age of Mosquitoes. Bettina Rosay and A. Ralph Barr, California State Department of Public Health, Fresno, Calif. Preliminary findings will be presented on the results of a survey of adult mosquitoes in a ricefield located in Fresno County, California. Evaluation of the population was based on the physiological age of mosquitoes as determined by dissections. *Culex tarsalis, Anopheles freeborni,* and *Anopheles franciscanus* were the dominant species. Behavior patterns, such as mating, feeding, and movements away from the field, were related to the ages of individual mosquitoes. Observations were made on the population increase at the beginning of the season and the re-establishment of the population after an application of insecticide. Adult movement was indicated by collections from artificial resting stations placed within and around the ricefield.

Observations on the Flight Activity of *Culex tarsalis* Coquillett in the Irrigated Areas of Southern Alberta. J. A. Shemanchuck, Canada Department of Agriculture, Vet-Med Entomology Section. Research Station, Lethbridge, Alberta. In 1956, 1957 and 1960 observations were made on the flight activity of *C. tarsalis* males and females. A visual attraction trap was used for sampling. An attempt was made to obtain quantitative as well as qualitative data on fly adults. Observations were also made on air temperatures, relative humidity and wind speeds.

Observations on the Meteorological-Mosquito Population Relationship at Stoneville, Mississippi, 1959. Jack Riley and Robert A. Hoffman, Weather Bureau, U. S. Dept. Commerce, and Entomology Research Division, Agric. Res. Serv., U.S. D.A. The *Psorophora confinnis* (Lynch Arribalzaga) mosquito population associated with pastures was correlated with meteorological conditions of rainfall, evaporation and soil temperature in order to attempt to establish a possible criterion for forecasting mosquito outbreaks. The observations indicate the complexity of topographical and weather factors involved in determining if a given area is capable of producing a mosquito problem. The preliminary evidence suggests that soil temperatures could conceivably be a more sensitive and consistent measure of the true mosquito larval habitat.

Observations on the Snow Mosquitoes of Nevada. Harold C. Chapman, Entomology Research Division, U. S. Dept. of Agriculture, University Station, Reno, Nevada. Snow mosquito breeding was recorded from early March to July at elevations ranging from 4,300–10,000 feet. Seven species, *Aedes cataphylla* Dyar, *A. communis* (DeGeer), *A. fitchii* (Felt & Young), *A. hexodontus* Dyar, *A. increpitus* Dyar, *A. pullatus* (Coq.), and *A. schizopinax* Dyar are reported as snow mosquitoes in the state. The latter species is designated as a snow mosquito for the first time in the literature due to its breeding habitat and companion species both in Nevada and California. Notes of a biological, ecological, distributional, and taxonomic nature are included for these species as they occur in Nevada.

Further Comments on the Susceptibility of *Aedes aegypti* to DDT in the Miami, Florida Area. John E. Porter, Burton R. Evans and George Kozuchi, Quarantine Station, U. S. Public Health Service, Miami Beach, Florida and New Orleans, Louisiana. *Aedes aegypti* larvae of the F_1 generation reared from specimens taken in 5 different areas of Miami, Florida showed varying degrees of susceptibility or resistance to DDT in 1960 tests using the standard WHO DDT-test kit methods. They range from larvae in

two areas with an LD-50 of 0.029 p.p.m. and 0.028 p.p.m. respectively to larvae from another area showing indications of resistance with an LD-50 of 0.22 p.p.m. Intermediate to these extremes were larval populations having an LD-50 of 0.138 p.p.m. It now takes up to 3 times as much DDT to obtain an LD-50 as was reported by Evans, *et al.* (1960) for *aegypti* from Miami.

Inheritance of Insecticide Resistance in Corvallis Strains of *Culex tarsalis* Coq. Frederick W. Plapp, Jr., Dale E. Borgard, and Gaines W. Eddy, Entomology Research Division, U. S. Dept. of Agriculture, Corvallis, Oregon. Studies were made on the inheritance of insecticide resistance in a malathion-resistant strain of *Culex tarsalis* obtained from the Fresno, California area in 1957 and in a DDT-resistant strain collected at Oak Ridge, Oregon in 1956. It was found that malathion resistance was dominant to susceptibility and that resistance to DDT was recessive to susceptibility. In all crosses segregation for resistance and susceptibility occurred in the F_2 generation in approximately a 3:1 ratio indicating that the transmission of resistance is monogenic in nature. No differences were noted between reciprocal crosses, indicating that the resistance is not sex-linked.

Laboratory Studies With Organic Compounds for the Control of Adults of *Aedes taeniorhynchus* Wied. A. N. Davis and J. B. Gahan, Entomology Research Division, Agr. Res. Service, U.S. D.A., Orlando, Florida. Wind-tunnel tests were conducted with adults of *Aedes taeniorhynchus* Wied., to compare the toxicity of a malathion standard and a group of organic compounds known to be toxic to other species of insects. Among the chemicals superior to the standard were four phosphorothioates, one phosphate, and one carbamate.

Oviposition Responses of *Culex quinquefasciatus* Say to Waters Treated With Various Chemicals. C. M. Gjullin, Entomology Research Division, U. S. Dept. of Agriculture, Corvallis, Oregon. The oviposition response of *Culex quinquefasciatus* Say to a series of chemicals was determined in cage tests. Several of the chemicals tested were repellent at 5 to 10 p.p.m. and some were more attractive than distilled water.

Relationship of Ventilation and Dosage to the Effectiveness of DDVP as a Residual Fumigant. W. Mathis, J. W. Miles, H. F. Schoof, Technical Development Laboratories, Technology Branch, Communicable Disease Center, Public Health Service, Savannah, Georgia. In residual fumigant studies at Savannah, Georgia, dieldrin-resistant *A. quadrimaculatus* were exposed overnight in buildings (1000 cu. ft. each) to DDVP vapor produced from 1 to 9 dispensers under three levels of ventilation. Satisfactory kills of specimens at 14 sites in the building were obtained up to 16 weeks. Mortalities were particularly sensitive to ventilation changes. With minimum ventilation, one dispenser gave equivalent effectiveness (11–12 weeks) to 9 dispensers under maximum ventilation. Concentration of DDVP vapor of approximately .01 microgram per liter of air gave satisfactory mortalities.

Residual Toxicity of Some New Insecticides to Adults of *Anopheles quadrimaculatus* Say. J. B. Gahan, G. C. LaBrecque, and H. G. Wilson, Entomology Research Division, Agr. Res. Serv., U. S. D.A., Orlando, Florida. This paper reviews the results of recent investigations conducted in Florida to develop new insecticides that can be used in residual spray programs against *Anopheles* mosquitoes. Both laboratory and field phases of studies on adult *Anopheles quadrimaculatus* Say are covered. The outstanding compounds were esters of carbamic acid.

Biology and Control of *Aedes sierrensis* in California. Robert F. Portman, The Butte County Mosquito Abatement District, Biggs, California and Leon L. Hall, Fresno Westside Mosquito Abate-

ment District, Firebaugh, California. *Aedes sierrensis* (Lud.) the western tree hole mosquito is frequently a severe, spring pest in some areas of California. Insecticide treatment of larval habitats and adult shelters has given complete control in many instances. Some olive groves have not become reinfested after eight years. A method for the determination of the presence of an infestation before breeding commences is given.

LAGOONS FOR SEWAGE, OTHER WASTES—AND MOSQUITOES? William E. Bickley and Jerry Mallack, Department of Entomology, Maryland State Board of Agriculture and University of Maryland, College Park. Shallow lagoons or so-called oxidation ponds appear to offer an economical method for sewage disposal in small communities. These ponds are being promoted by various health and public works agencies. Many lagoons have been constructed and operated without creating mosquito problems, yet this type of pond is undoubtedly a potential source of mosquito breeding. Some small lagoons built for holding certain industrial wastes such as waste from canneries provide optimum conditions for *Culex* spp. Control is very difficult. There is a need for additional information about the chemical and biological processes within these disposal lagoons in relation to mosquito production.

SOME CURRENT TVA MOSQUITO CONTROL ACTIVITIES. Gordon E. Smith, Tennessee Valley Authority, Wilson Dam, Alabama. In carrying out its responsibilities to the states and people of the region, TVA has expanded its mosquito control measures to include the control of certain pest species as well as the malaria vector. Through research, planning, and field application of new techniques, repetitive costs have been reduced considerably by establishment of naturalistic control through shoreline improvement, water level management, and by improvement in supplementary control measures.

Mosquito egg counts are made from soil samples taken at known reservoir contours at strategic locations to determine the production potential of floodwater species. Pest broods are prevented by water level manipulations or by preflood treatments of the soil. Helicopters are used in applying preflood treatments, for larviciding, and for herbiciding.

Hand clearing operations of reservoirs have been largely replaced by heavy tractor-powered cutter blades, rakes, and disks. Rotary mowers are used in shoreline maintenance and extensive use of dynamite is employed in ditch maintenance.

MOSQUITOES IN INTERNATIONAL AERIAL TRAFFIC ARRIVING IN THE UNITED STATES. John H. Hughes, U. S. Public Health Service, Division of Foreign Quarantine, Washington, D. C. Mosquitoes are commonly transported in international aerial traffic arriving in the United States. The Public Health Service Division of Foreign Quarantine has an entomology program directed toward prevention of introduction and establishment of mosquitoes and other insects of medical significance.

RECENT CHANGES IN *Aedes nigromaculis* LUDLOW POPULATIONS IN THE SALT LAKE CITY MOSQUITO ABATEMENT DISTRICT. Glen C. Collett, Salt Lake City Mosquito Abatement District, Don M. Rees, University of Utah, Salt Lake City, Utah. Survey records indicate *Aedes nigromaculis* were collected in the vicinity of Salt Lake City in the late twenties and early thirties although very few collections were reported. Rees (1930) states *Aedes nigromaculis* is not very numerous in the district but was found this season west of Salt Lake City. Again in 1935 this species was reported as occurring in the district.

In the seventeen-year period from 1935 to 1952 *Aedes nigromaculis* were collected in the light traps only in 1945 and 1948. In each of these years single collections were recorded.

Since 1953 this species has increased in numbers in the vicinity of Salt Lake City. It is now frequently found in considerable numbers as larvae and adults, especially in the irrigated areas.

Seasonal Observations of the Nulliparity of *Culex tarsalis*. Jack S. Blackmore and Richard P. Dow, Encephalitis Section, Public Health Service, Greeley, Colorado. Studies of the parous or nulliparous condition of *Culex taralis* were conducted through the season in areas of high and low mosquito population densities. It was found that during the season the percentage of parous mosquitoes increased until by late August, all the mosquitoes collected in CO_2 traps were parous. In contrast, the percent parous in resting shelters decreased until this segment of the *Culex tarsalis* population was 100 percent nulliparous. *Culex tarsalis* moving up a canyon area, presumably for hibernation, showed all specimens tested to be nulliparous. This suggests that *C. tarsalis* is not involved as a winter reservoir of encephalitis viruses at this latitude.

Studies of the Nature of Resistance to Malathion in *Culex tarsalis* Coq. Frederick W. Plapp, Jr., Walter S. Bigley, and Gaines W. Eddy, Entomology Research Division, U. S. Dept. of Agriculture, Corvallis, Oregon. *In vitro* studies have consistently failed to demonstrate any hydrolysis of either malathion or malaoxon by larvae of either resistant or susceptible strain of *C. tarsalis*. However, *in vivo* studies which utilized enzymatic techniques of analysis have provided evidence that larvae of the resistant strain detoxify malaoxon more rapidly than do larvae of the susceptible strain. Low levels of ali-esterase which appear to be a factor in house fly resistance to organophosphates are apparently not involved in malathion resistance in this species.

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EARL L. GISH

We are especially saddened to have to record here the death of Earl Gish, which occurred, truly, "in the line of duty," at the end of the AMCA-CMCA meetings at Anaheim, Calif. John H. Pritchard, Business Manager of the Jefferson County Mosquito Control District, Nederland, Texas, sent in a clipping from the Port Arthur News of February 4, 1961 from which the following excerpts were taken.

"Mayor Earl L. Gish of Nederland, who defied a heart ailment to work for the city and area he loved, is dead at the age of 59.

"The man who lived at a tireless pace in contradiction to his precarious condition, died doing the work he liked best—traveling to promote the interests of the county and Nederland.

"Funeral arrangements, to be handled by Weldon Davis Funeral home, were incomplete today.

"Death came Friday from a heart attack at a Los Angeles, Calif., airport where Mr. Gish had just boarded an American Airlines jet for a trip home.

"The 2½ hour flight to Jefferson county airport was apparently only minutes away from its scheduled 6 p.m. (CST) departure.

"The longtime civic leader and public servant was on the West Coast for a week, pursuing one of the numerous related duties he welcomed while serving as head of Nederland's city government.

"On his final trip, the mayor had attended a convention of the American Mosquito Control Association at Anaheim, Calif."

LEON HALL

On Sunday afternoon, January 15, Leon Hall, Manager of the Fresno-Westside Mosquito Abatement District, suffered an acute heart attack and died instantly.

The previous Friday, Lee had attended a meeting of the Southern San Joaquin Valley Region held at Visalia. He was in his usual buoyant spirits and there was no indication of impending trouble. At this meeting he was selected to serve this region as its regional representative. He accepted with modesty and volunteered to do his best in the interest of good mosquito control.

Since entering mosquito control in Butte County a few years ago, Lee worked hard and faithfully for the CMCA. He was a member of the Entomology Committee for several years and assisted in the preparation of the "Guide To Common Mosquitoes of California." For two years he served as chairman of the Insecticide Committee and guided this committee in its preparation of a revision of the insecticide bulletin.—(From a memorandum to the California Mosquito Control Association, by W. D. Murray.)

CORRECTION

With reference to an error in the AMCA history published in *Mosquito News*, Vol. 20 No. 4 (December, 1960), page 397, the chairman of the committee which prepared the History has authorized the following correction:

"At the fifth meeting of the Eastern Mosquito Control Association, the predecessor of the American Mosquito Control Association, held in August, 1939 at Bay Shore, Long Island, New York, Mr. C. T. Williamson was elected President, and held that office through the year, until the next meeting in 1940. The History as published in *Mosquito News* wrongly listed Dr. Headlee as President and 'W. S. Corkran' as Vice President. The committee regrets this error and is glad to have been given this opportunity to set the record straight."

Incidentally, the Historical Committee earnestly solicits corrections of any similar or other errors that are noted in the History.

NEWS AND NOTES

AUSTIN W. MORRILL, Jr.

The Meetings in Disneyland Hotel Were a Great Success Both in the Exchange of Fascinating Information and in Pleasant Settings to Renew Old Friendships. Everybody connected with the arrangements deserves and got a huge vote of thanks for their tireless and productive efforts. Jack Kimball managed to look calm and as if he were enjoying himself as he dashed about seeing that projectors worked and tours got off on schedule. Norman Hauret had done a superlative job of arranging the exhibits and introduced a new wrinkle that really pepped people up. Each exhibitor had a roll of tickets . . . different each day . . . and after you had stood and talked about The Product long enough you were rewarded not only by knowing more than you did, but also by receiving a bunch of tickets. We suppose that the number you got depended on how attentive you were. We averaged two at each place, but we were sort of letting our eyes stray around to take Notes on Things. At the end of the day a drawing was held and prizes handed out. They were pretty good prizes, too, and this increased the attendance at the last few papers each day quite a good bit. Not that the papers weren't good, but you know how it usually is by the end of the day's sessions. Not this time, though. Everybody present.

The meetings were dedicated to Stan Freeborn whose presence seemed very near to all of us. Harold Gray summed the feeling up in his opening paper of the meetings, as did the tribute in the program which ended, "Dr. Stanley B. Freeborn, we salute you and shall long reap the rewards of your warm comradeship, wise counsel, and extremely productive career." The frontispiece was an excellently reproduced snapshot closeup of Stan, which we hope will go into the proceedings. This reproduction, by the way, and the rest of the beautifully printed program, was the workmanship of John Shanafelt, about whose hobby printshop we told you a few issues ago. Bob Peters deserves special mention too, we think, and his fine committee, for arranging the caravan up the valley to visit the laboratories.

Our New Vice-president Is Don Micks, who presented a Summary of the Significant Research Developments During 1960 which was so well arranged and so thoroughgoing that it will provide a most valuable reference index for us all, and we know you will want to make note of it. We are not the ones to bring you abstracts of the papers, many of which abstracts are being published for you in the *News*, but we do want to mention a couple of others you will want to refer to a good many times in the future, we are sure. One was Bob Metcalf's usual scholarly but brisk summary of the methods of development of new insecticides for the control of mosquitoes and other arthropods of public health significance. He explained the intricate but well-coordinated interrelationships between the WHO-sponsored laboratories in England and elsewhere, Tony Brown's labors in Canada, the Orlando lab (which was represented at the meetings by Jim Gahan), the Savannah lab of CDC (represented by Herb Schoof), and others around the world. And he pointed out fascinating bits of information being obtained as a "side effect" on the mechanics of resistance.

He was followed by Bill Upholt, who remarked that he had always been terrified by the idea that some day he would have to get up and try to give a paper following one by Bob and it had finally happened to him. Then he went on to give an equally definitive and absorbing account of the Evaluation of Public Health Hazards of Pesticides, including a bit on DDVP, of currently increased interest. He was followed by Don Micks' paper, mentioned above and it isn't often that one gets *three* top-flight papers right in a row. Left us groggy it did. But feeling mighty well informed and intelligent.

There Were 382 Registrants of whom 236 were from mosquito abatement agencies, 44 from health departments, 11 from educational institutions, 15 from agricultural departments, 7 from the Armed Forces, 44 commercial representatives and 21 who represented scientific laboratories, WHO and other UN activities or other agencies. There were a goodly number of the fair sex, both as delegates and as wives and this made the dinner dance nicer and lots of people stayed after the dinner was over, dancing and having a fine time. (The food was really good, too . . . squab and wild rice and all that sort of thing.)

We Can't Leave This Fascinating Subject Without Bringing You a Couple of "Joaks" we enjoyed in the course of the speeches. The Honorable Carley V. Porter, California State Assemblyman from Orange County, who had obviously done his homework very well indeed and richly deserved the laudatory introduction he had received, commented that all his activities seemed to add up, if he really did all that, to so much time he'd have little for sleep, and that in case anyone wondered When he slept, it was during these long introductions! Not to be outdone, Jack Chrisman, Mayor of Visalia who gave a fine summary of the impact of mosquito control on urban interests, started his address with some quite relevant statistics and added that of course statistics could be made to support anything . . . especially statisticians!

These Papers Will Be Brought to You by the California Mosquito Control Association in their Proceedings, which will be mailed out to all AMCA'ers by Ted Raley in August. Don Grant, their editor says copies will be available from Don Murray *after that date*, but don't think you were missed if you don't get them sooner.

OTHER NOTES scribbled in the dark on our program margins include greetings from New Jersey, brought by BAILEY PEPPER; from Canada, brought by D. G. PETERSON; and from Nicaragua, by JOHN STIVER. John won a case of pineapples for coming the furthest and there's a story there, too. AL WATANABE, ably assisted by the Dole Pineapple people and United Air Lines, arrived from Honolulu accompanied not only by PAT NAKAGAWA but by 250 pounds of ripe, wonderfully edible pineapples. This is an obvious pitch to get us to meet out there, now that California has become centrally located in the United States, and we're all in favor of its ourselves. In addition to John Stivers' award, Desplaines MAD was trophied for having three trustees with a combined 82 years experience in mosquito control. HAROLD GRAY easily accounted for 50 years on his own, LESTER SMITH acknowledged 40, PHILIP FELLINGER, of Essex County (New Jersey), reported a start in mosquito control dating from Panama in 1910, and DON REES came up with 26 years, a mere beginner.

LET'S SEE . . . the ladies' favors were Golden Oil Bathettes . . . a sort of Tossits, tastefully filled with bath perfume but voted apropòs to the meeting nonetheless. WILLIAM LASCHINSKI, super of the North Shore MAD (Illinois) was advised by the President of his District to give up bowling. San Joaquin (California) MAD had SEVEN trustees present. California M.C.A. elected LES BRUMBAUGH prexy and DAVE REED Vice. JOHN BRAWLEY is pres-elect. AND LOTS MORE . . . YOU SHOULD OF BEEN THERE!

ONE THING ALL AMCA'ers agree on is that the better the mosquito control, the more people holler about the few mosquitoes there are left. In the VIRGINIA MOSQUITO CONTROL ASSOCIATION'S *Skeeter* recently, a report was given on the results of their light trap program. Twenty-three traps were operated from 20 May to 22 September and the total *Aedes sollicitans* and *Aedes taeniorhynchus* collected in all that time was only 2,342. Local mosquito control men, *Skeeter* remarked, can remember just a few years ago when one light trap would catch three times that number in ONE NIGHT. The mosquitoes are the one thing in Colonial Williamsburg that haven't been restored to resemble the original, says *Skeeter*.

THE SAME ISSUE REPORTS ON A NEW TYPE FOG MACHINE which the Washington District (Virginia) feels is mighty, mighty good. Some of you may have seen this machine (there was one at the Meetings) and may want to learn more of the Virginia findings. In brief, during four hours operation per trip, the machine averaged 40 gallons water, 21 gallons butane, 3 gallons of gas for the jeep, and . . . we guess . . . some insecticide. The operators found the machine quiet, dependable, easy to operate and productive of a good, even-sized but copious fog. If you like fog. . . .

SPEAKING OF MEETINGS, the Northern California Entomology Club held its thrice-yearly meeting at the University of California at Davis, on 10 February. JACK FOWLER gave a fine paper on the use of Quaternary Ammonium Compounds as mosquito larvicides. His findings sounded so encouraging that we sure hope he'll write it all up for an early issue of *Mosquito News* . . . or at least send it in as an Operational and Scientific Note. Dr. Harry Lange reported on anti-feeding compounds which inhibit feeding by insects attacking vegetation, but one of these turns out to sterilize flies . . . so we sort of pricked up our ears on that one, too. BOB DOLPHIN gave a discussion of his Clear Lake gnat research and control program that really had us crying in sympathy. Seems as if he's tried everything except getting some Hollywood wind machines and blowing all the eggs into a bunch on one side of the Lake and then spraying them with oil and setting fire to them. But just when our sympathies were at their most sentimental, he let the cat out of the bag that his folks were really kind of hoping that some of the rest of us would turn up with a few *Chaoborus sticticus* . . . misery loves company, you know. That did it.

WE DID HAVE IT ON THE BEST AUTHORITY BUT our prediction about COLONEL RALPH BUNN couldn't have been wronger. Seems he is now the Chief of the Scientific Analysis Branch, Life Sciences Division, Army Research Office, Chief of Research and Development, U. S. Army, Washington 25, D. C. Ralph's new assignment is of considerable importance to Military Entomology and so we can't be too sorry about his not having to work out in the broiling sun on those hot Florida beaches.

G. B. CRAIG, JR. and two cohorts had an extremely provocative paper in *Science* not long ago on "An Inherited Male-Producing Factor in *Aedes aegypti*." This subject also came up for a number of discussions at the Meetings and looks like a hot lead. Like the business of sterilizing males and utilizing maturation hormones, this sounds like fantasy but may end up a major advance in control. The male-producing factor appears to be transmitted only by males and is not due to differential mortality, at least in postgametic stages, which means after the embryo is formed, in loose English. We think.

ROY FRITZ IS ON HIS WAY TO MANILA, DJAKARTA, BANGKOK and all those wonderful places but may be back by the time you see this. That is how fast Roy moves. He stopped off for Disneyland, though, and also gave us word of FRED SOPER, who is en route to Dacca, in East Pakistan for two years work in plague control study. His address, by the way, is American Consulate General, APO 143, Box DAC, c/o Postmaster, San Francisco.

One of Leon Hall's Last Acts in the Organization of His Increasingly Successful mosquito abatement district in Firebaugh (California) was to sponsor a meeting in his fine new buildings, where Earl Mortenson showed the CDC film entitled, "Biology and Control of Domestic Mosquitoes." The meeting was a big success and the film and the buildings drew equal praise.

We've Just Finished Tabulating the Index as We Write This (and it should be reaching you in this same issue) and Boy! Mir Mulla has won the Authorship Derby hands down. It's kept us slaving over a hot typewriter just to *index* all the titles, we can tell you, and what it must have done to him to write the papers! We shudder to think. To say nothing of the research time. He must have worked by candlelight many a night. Nothing mere about Mir. Well, it's mighty fine digging for us armchair types who get our scientific knowhow by picking other people's brains. Now if he'd just put in a few mnemonic aids so we could retain all this. (We guess that's what indices are for, isn't it? . . . so we can look up what we couldn't remember.) So, hats off to AMCA's Emir!

We Got Interested In This, rather, so we counted up on some other folks, too. Larry Lewallen was next with four and R. O. Hayes had three. He had three in 1958, too. Ed Loomis, Chappy Chapman and Don Rees were the leaders in 1959, tied with three each. None of these fellows let any grass grow under their feet, either, in other scientific publications, by the way. We started to corner Mir at the meetings and ask him how he accomplished all this (he had four papers) but he was always so deep in earnest-type conversations we hadn't the heart to interrupt with our frivolities. We did get some biographical dope from him, though, of which more later.

When the Entomological Society of America Issued Its Latest List of Insect Common Names Recently, We Were Delighted to Discover that Southern Coastal AMCA'ers have succeeded in our dream of years, eradication of the southern salt marsh mosquito, *Aedes taeniorhynchus*. It's nowhere, Man. We thought for a moment that maybe it was AMCA'ers Ken Knight and Alan Stone, who might have eradicated it with one stroke of the pen in their recent definitive "Synoptic Catalogue of the Mosquitoes of the World" but, no . . . thar it is. So congratulations, VMCA and FAMA and all you other mosquito control organizations from the Lesser Antilles to California! And Hi, ESA!

(We Asked Johnny Mulrennan, Sr. About This and He Just Looked Mysterious) While We're On the Subject of Salt Marshes, You Will Remember That In the Last Issue We Asked for information on the flight range of *C. salinarius*. George Thompson reports that in asking around he obtained information from several sources who had clocked these pests at considerably greater distances than most of us gave them credit for. From Harry Pratt and Rollie Dorer came a report of flights of from ten to nineteen nautical miles at Norfolk, Virginia. (A nautical mile, for you landlubber types like Us, is one and one-eighth miles on land, so Rollie has some handsome aquatic areas in his baliwick.) A report from Delaware mentioned flights of 12.8 kilometers and 5 kilometers, respectively. And of course, you know what *that* is. Too far, that's what.

Don Pletsch sent us a card from Mexico City, to which he returned after a very exciting look at the tremendous malaria eradication program being carried out by the Indian Government, with substantial U. S. support. Don says he had the pleasure of working with a number of ICA experts and people on loan from TVA and such. "After a breath-taking orientation at the program headquarters in New Delhi, where we were treated most hospitably—and instructively—we had the privilege of visting all but one of the State malaria organizations and seeing how some of the 390 malaria units are protecting almost 400 million people in their respective jurisdictions."

Harry Stage Writes That He Has Retired Again and this time, finally and irrevocably and forever. We'd hoped to find out at Disneyland where this meant he was going now, but unfortunately he couldn't show. We'll find out and report. He Says it's for good, though, and he's just going to set and fish and sometimes just set.

Another Perennial Un-Retirer Is Harold F. Gray, who has stepped out as a sanitary engineer this time. As ex-virologist, ex-mosquito abatement manager, ex-author, Dr. Gray claims he's just returning to his original ex— sanitary engineer. "The water company up here needed an engineer to watch the contractor building the Western Pacific Railroad relocation," Harold said, in a letter to Helen Louise Durkee, "to get the tracks out of the Feather River Canyon, where the big dam is to be built. The new road runs parallel to the ditch which brings water to Oroville and no chances could be taken to have the supply interrupted or contaminated. Hence me." Harold looked in the pink of health, we were glad to see, and told us at Disneyland that he looked forward to being a sanitary engineer again but didn't plan to ignore any mosquitoes that might try to get into the water supply.

Some of You Have Wondered What the Intriguing and Informative Notes Ted Raley Sends Us from Time to Time *ARE*. Ears were pricked up, hoping for gossip maybe. (How

could anyone accuse Us of THAT?) Well, the notes are lists of new members and changed addresses, that's all. What makes them fascinating is that they don't always tell *all* to anyone like us who hasn't been paying close attention, maybe. Like is this a new member or isn't he, man? Regardless of this, we want to welcome R. C. BUSHLAND of the Kerrville, Texas laboratory and JOHN A. FLUNO of Beltsville, and Dr. JOSE MENDOZA, of the Department of Health, in Manila, and Dr. FRANCISCO F. BAISAS of the Malaria Bureau there. Like the AMCA'ers we mentioned in a recent issue, we thought they'd been members right along and are mighty happy that they are now. We'd like to welcome Drs. FERREIRA and GALVAO of Brazil, too, and Drs. NIETO-CAICEDO and ROZE of Venezuela and HERIBERTO A. TREVINO of the USPHS at Brownsville, Texas, and all you other new AMCA'ers, who we hope will send in News and Notes about themselves and their work and their gadgets and methods. Come In!

WELL, WE NO SOONER GIVE YOU THE SCOOP ON SOME PEOPLE THAN THEY GO AND CHANGE IT. We had told you about Dr. STEPHEN M. K. HU, who *was* USOM Katmandu, via the State Department, Washington 25, D. C. He still is in Katmandu, we hear, and hasn't really moved, but his address now is USOM/N, APO 143, Box KAT, San Francisco, California. You acrostic fans won't have any trouble with *that*. DICK GERHARDT, who we told you is now at Adams State College, has sent word that Adams State College is in Alamosa, Colorado. And will whomever the following membership is *for* please send us word of who he IS, before we lose our minds out of curiosity? It's: Post Engineer Supply, Hqs, U. S. Army Japan, APO 343, San Francisco, California, which used to be in Yokohama. And Welcome, Mr. Post Engineer Supply!

THAT SAME FORMER FRIEND WHO HAS SENT US HOMELY TRUTHS ABOUT OURSELVES BEFORE, now opines that he thinks it would do us good to ponder the fact that some people have a good aim in life, but somehow never seem to pull the trigger. Hm.

DON GRANT'S SAN MATEO (CALIF.) MOSQUITO ABATEMENT DISTRICT is happily building an addition on their plant which will double the floor capacity and about quadruple the effective use-space. His old, present building will then house offices, laboratories, dark-rooms, library and conference space, and the new building will house gear, vehicles, shops and a lift rack.

YE ED, (OUR BOSS) IS MODESTY ITSELF AND IN CASE HE DOESN'T PRINT HIS REPORT TO THE BOARD OF DIRECTORS we think you should know that under his direction, *Mosquito News,* the Journal of the American Mosquito Control Association, has not only risen to top flight as a scientific and operational journal, but has reached its twentieth year of publication with an issue of 1000 more copies per volume than only four years ago. There were 1700 copies per issue this past year and this was raised by 100 just this month, so that 1961 will see us sending out 1800 copies per issue. This means not only a healthy growth in membership and an increased value to the libraries all over the world which increasingly find they must have us to keep abreast; it also means a vastly increased value of our pages to our valued advertisers, who are reaching more people and more carefully selected people as their audience each issue. Pages per issue increased, too. Operational and Scientific Notes, for instance, increased 9 pages in volume 19 and 21.5 in 1960, about one-tenth of the total pages. And we need more O and S Notes, pals everywhere. If you have a gadget or a technique you find useful, pass it around. If you don't want to write it up into a note, send it to your Regional Director or to us and we'll do it for you. Just send them in (Adv.) Hi, Don! (Guess I'm on the spot, so if I may morrillize a bit, I'll let this pass.—Ed. Note).

ONE SAD NOTE MARRED THE END OF THE MEETINGS and we should like to convey our deepest sympathies to the family and colleagues of Mayor Earl L. Gish, of Nederland, Texas, who died on the plane in which he was about to take off on his return trip. He had been a delegate with the Jefferson County Mosquito Control Commission and we had had several stimulating chats with him, much to our enjoyment. He seemed to enjoy the proceedings himself and had shown that informed and alert concern for good mosquito control programming which is so wonderful to have in our commissioners.

OUR WHO'S WHO PRESENTATION THIS TIME IS THE REDOUBTABLE, ENERGETIC AND CAPABLE MIR S. MULLA. Mir was born in Kandahar, Afganistan, near the Khyber Pass, in 1927, the year Lindbergh flew across the Atlantic, ending forever the world of impassable distances and impregnable continents. Whether or not this inspired Mir as he grew up, he reversed the flight by coming to America, where he attended Cornell University and received his B.S. in Entomology there in 1952. His Ph.D. at the University of California at Berkeley followed three years later and since that time he has been at the University of California at Riverside, where he is Assistant Entomologist. During these past five years he has ferretted out many basic and interesting facts about the many facets of the biology, ecology and control of both mosquitoes and related gnats, particularly the *Hippelates.* His hobbies (he has time for hobbies?) are tennis, hiking and electronics. Good for sunny days and rainy days, winter days and summer ones. We bet he plays a scorching game of tennis. If he learned to hike going over the Khyber Pass, we probably couldn't keep up with him there, either.

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ERRATUM

In Mosquito News 20(4):415 under Behavior, Biology and Ecology section change pages of reference by Peters and Standfast to read 249–254.

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